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Discussion of all papers is invited

VOL. 17 JANUARY, 1927 No. 1

THE HYDRAULIC JUMP AS A MIXING DEVICE[1,2]

BY A. G. LEVY[3] AND J. W. ELLMS[4]

The hydraulic jump may be defined as that phenomenon in which a part of the kinetic energy of a stream of water flowing in an open channel, at less than the critical depth, is converted into potential energy in the attempted turbulent passage from the lower to the upper alternative flow level. These alternative levels are the only two possible levels for steady flow under a given energy condition; and the critical depth is that depth at which the alternative levels coincide. For any given channel section and given quantity of water, the critical depth is a constant, and represents the minimum amount of energy for that particular set of conditions. In other words, the critical depth for any given discharge per unit width is that depth for which the value of the sum of the depth and the velocity head is a minimum.

In considering the alternative flow levels in an open channel, it must be borne in mind that the passage from the low to the high

[1] Presented before the Water Purification Division, Buffalo Convention, June 11, 1926.

[2] U. S. Patent 1,362,611, December 21, 1920.

[3] Engineer of Construction and Surveys, Division of Water, Cleveland, Ohio.

[4] Engineer of Water Purification and Sewage Disposal, Division of Water, Cleveland, Ohio.

stage is possible under two conditions; namely, (1) without the presence of any turbulence, and (2) by means of the jump, involving loss of energy through internal impact. The first case can never happen except by the interposition of a force external to the water itself and the second can take place only through the loss of energy within the jump.

These conditions necessarily follow from the theories of the conservation of linear momentum and energy. Because of the loss within the jump, the upper alternative theoretical flow level can never be actually reached, although it is the attempt of the water to pass to it which results in the jump taking place.

The hydraulic jump, as a phenomenon of nature, occurs along lake and sea shores under certain conditions of beach formations. It is found at the foot of high dams and occasionally in channels for irrigation works. It is often a source of trouble and requires special care to avoid its occurrence whenever any condition exists which causes retardation of velocity in a stream flowing much below its critical depth.

The hydraulic jump has been studied experimentally for over one hundred years. According to the technical report of the Miami Conservancy District, Bidone's results, published on pages 21 to 80, in the Transactions of the Royal Societies of Turin for the year 1819, are the earliest on record. Professor Gibson, Ferriday and others, and lately Lane, Kennison, Hinds, and Riegel and Beebe, have made similar studies. With the exception of the work conducted by Riegel and Beebe for the Miami Conservancy District all experiments have been made upon small flows of water. The work carried on in the Cleveland experiments involved quantities, varying from a minimum of approximately 20 to a maximum of 42 cubic feet per second. These volumes are roughly from 2 to 4 times as large as any heretofore handled experimentally.

The hydraulic jump, while a common phenomenon in nature, has, so far as the writers know, been utilized only occasionally, and then solely for the dissipation of energy in flowing water. Engineers have employed the hydraulic jump with the idea of changing a high velocity of flow, which would cause scour, into the more stable and less destructive low velocity. In no case, however, so far as we are aware, has an attempt been previously made to convert the energy within the jump itself into useful work.

It was thought that the churning action therein would furnish a

cheap and efficient means for thoroughly mixing water, being prepared for filtration, with the chemicals applied. In order to test this hypothesis, it was necessary (1) to study the action of the jump from the standpoint of a method for chemical mixing, and (2) to investigate, on a sufficiently large scale, its practicability for the conditions required in good filtration plant design. Both of these objectives were attained as a result of the Cleveland experiments.

In principle, the hydraulic jump and mixing flume, together with the phenomena of which the jump is a part, are shown on figure 1. As may be noted, the mixing device consists of an approach with a rounded entrance to the narrow section or throat, the latter leading to an expanding flume set on a slope. This flume is followed by a lower pool from which, in general, some type of control section leads to the exit channel. As the water enters the throat, it drops to its critical depth. From this point, it is theoretically possible for it to move along either the upper or the lower alternative flow levels, but because of the sloping, expanding flume, and because the surface of the tail water; viz., the water in the lower pool, is below the upper alternative flow level, the water is forced into the lower flow level until it meets the tail water where it attempts to jump to the higher level at the section marked "location of jump." As shown, the tail water depth is its distance above the floor of the lower pool at a point where the water is sensibly level and the loss of head is the difference in elevation between the surface of the water in the upper pool and that in the lower.

DESCRIPTION OF APPARATUS

The investigations of the hydraulic jump as a chemical mixing device were carried out by the Cleveland Water Department under the direction of the writers. The experimental plant was located at the Kirtland Pumping Station, situated on the Lake front at East 49th Street. The apparatus, as originally built, consisted of a stilling chamber, approximately 20 feet long by 10 feet wide by 9 feet deep with a baffle 3.95 feet high, which extended across the chamber, approximately 17 feet distant from the end at which the water entered. Leading from the other end of the stilling chamber and approximately 3 feet above the bottom was an expanding flume, having a sharp entrance, 4.90 feet wide at the narrow end, and 10.22 feet wide at the opposite end. The expanding flume was 20.72 feet long and had a drop of 3.06 feet in its entire length. This flume led

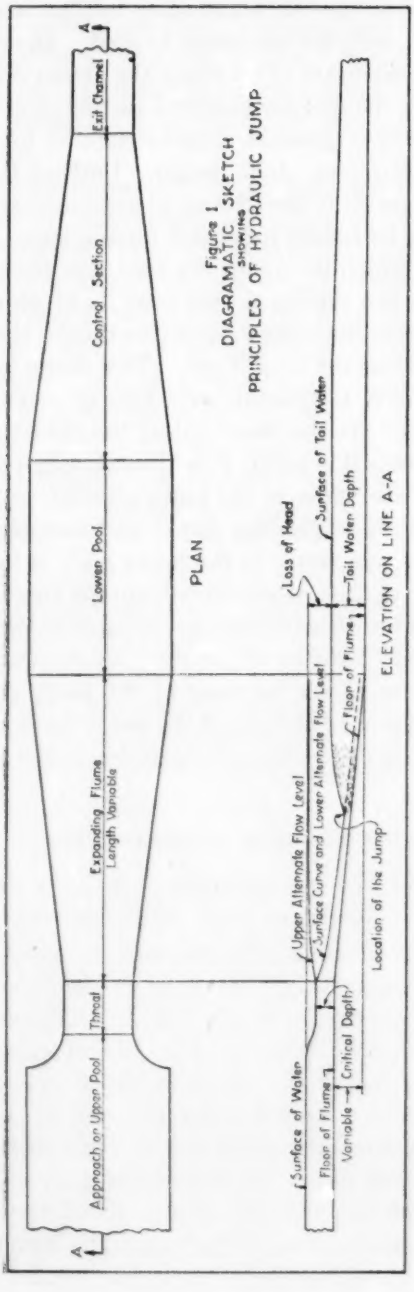
Figure 1
DIAGRAMATIC SKETCH
SHOWING
PRINCIPLES OF HYDRAULIC JUMP
PLAN
ELEVATION ON LINE A-A
A
A
Approach on Upper Pool
Throat
Expanding Flume
Length Variable
Lower Pool
Control Section
Exit Channel
Loss of Head
Surface of Tail Water
Tail Water Depth
Floor of Flume
Upper Alternate Flow Level
Surface Curve and Lower Alternate Flow Level
Location of the Jump
Surface of Water
Floor of Flume
Variable
Critical Depth

FIG. 1

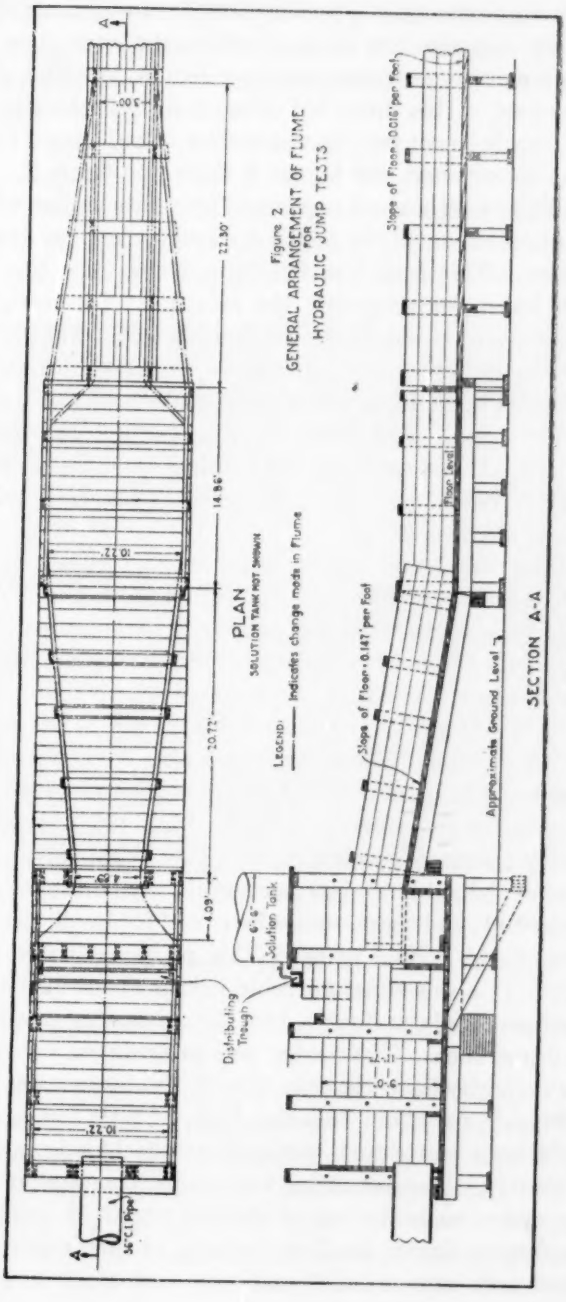

Figure 2
GENERAL ARRANGEMENT OF FLUME FOR HYDRAULIC JUMP TESTS

Fig. 2

into a chamber approximately 14 feet by 10.22 feet wide. At the end of this chamber, opposite the point at which the expanding flume entered, was an exit flume approximately 3 feet wide with a slope of 0.016 feet, per foot. This flume led directly to the lake shore and was intended merely to convey the water after it had passed through the jump. As constructed, the layout is shown on figure 2.

Over the stilling chamber and supported by struts on line with the baffle, was a platform on which rested a circular chemical tank, 6.5 feet in diameter. This tank was fed by a 2-inch pipe line which furnished the water for preparing the solution. For mixing and dissolving the chemicals, an air and steam pipe grid was placed in the tank near the bottom. A drain line led from the bottom of the tank to the ground level, from which point sludge and etc., could be flushed into the sewer. Just alongside the platform on which the chemical tank stood, and spanning the width of the stilling chamber was a box with V notch weirs cut in the side. Chemical piping led from the tank to the weir box.

For measuring depths of water, glass gauges were placed at approximately 2-foot intervals along the wall of the expanding flume and at two or three other strategic points. The entrance to these gauges was near the floor of the flume and flush with the inside face. One-eighth-inch piping, made in the form of quarter bends, were driven through the flume wall with one leg of the bends standing vertically on the outside. The glass gauges were connected to these pipes with rubber tubing, and were held by clamps to gauge boards on which were scales graduated to 0.01 of a foot. To prevent surging a laboratory clamp was placed on each rubber connection.

The gauges, explained in the last paragraph, were ultimately found to be unsatisfactory, and there were substituted for them, that which we have termed the forked gauge. This gauge consisted of two parts; namely, (1) a one-sided movable bridge about 12 feet long, spanning the flume walls, and (2) a fork for measuring to the water surface and flume floor. The bridge was so arranged by means of fixed wedges under its floor, that the side of the former was always vertical. This side was about 15 inches high, with its top, a straight edge. Parallel lines were drawn vertically across the side and spaced on 0.1 foot centers. The measuring fork proper consisted of a long-handled Tee square with the top of the Tee about 12 inches long. Into this head were driven headless nails on 1½ inch centers. The points of these nails were rounded and were each made to protrude

exactly the same distance from the head of the Tee. The handle of the Tee was graduated to 0.01 of a foot.

As the experiments progressed, the principal modifications made in the original flume, aside from the method of measuring the depths, were the substitution of,

1. A rounded approach to the expanding flume, in place of a sharp entrance.

2. The erection of a platform in the stilling chamber at the elevation of the approach to the expanding flume and extending across the chamber from the baffle wall to the flume entrance.

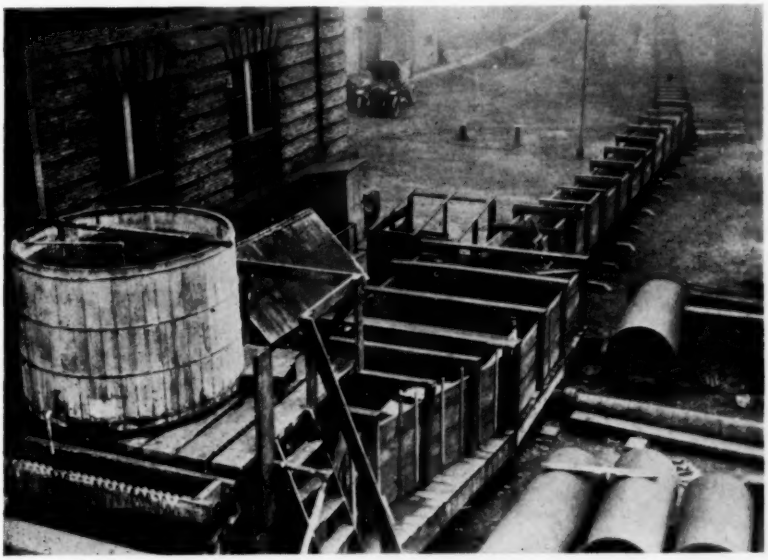

FIG. 3. EXPERIMENTAL FLUME

3. The cutting down of the baffle wall to the elevation of this platform.

4. The construction of a gradual approach to the 3-foot outlet flume, and

5. The changing of the chemical application from a point just before the baffle, to the entrance to the expanding flume.

Most of the chemical mixing experiments as well as the hydraulic studies were made on this modified apparatus.

Water for the hydraulic experiments was chlorinated raw Lake Erie water, and was supplied by a 30 million gallon steam turbine

driven centrifugal pump. The water entered the stilling chamber through a 36-inch pipe and was measured by a Venturi meter with a mercury manometer.

Another view of the original apparatus is shown on figure 3.

OBJECT OF EXPERIMENTS

In the study of the various hydraulic phenomena, their practical application to water purification plant design was the object sought. The measurements made and the deductions drawn have been found to be accurate as has been proved by the results obtained by the operation of the three large hydraulic jump mixing flumes, incorporated in the construction of Cleveland's new 165-m.g.d. filter plant.

HYDRAULIC DATA

During the course of the experiments, an attempt was made to study the action within the jump itself, by means of the Pitot tube. This attempt was unsuccessful in so far as quantitative values were concerned, but was highly profitable from the standpoint of qualitative results. It was found that, at various points, the velocity would gradually build up to a maximum, then, with apparently no change in the flow conditions, the Pitot tube would suddenly indicate a reversal of the direction of the flow, building up again to the maximum velocity. This phenomenon would frequently be repeated and for no observed causes. There was apparently no regularity about its action. The increase in velocity was sometimes slow and sometimes rapid. At times, the Pitot tube would indicate a flow in one direction, at the maximum velocity, for a period of five minutes or more; at other times, as soon as the flow in any direction had reached its maximum velocity, it would be suddenly reversed, indicating that there were many forces in operation which caused numerous currents and counter-currents within the jump and which produced a violent agitation and commingling of the water, all of which contributed to remarkably effective mixing action. Some idea of the multiplicity of currents and counter-currents existing in the hydraulic jump may be obtained from figures 4 and 5.

On figure 6 is shown one of the three 55 m.g.d. capacity hydraulic jumps at Cleveland's Baldwin Filtration Plant. These large flumes were designed on the basis of the experiments herein described. It shows the practicability of designing and building mixing flumes of this type of any desired capacity.

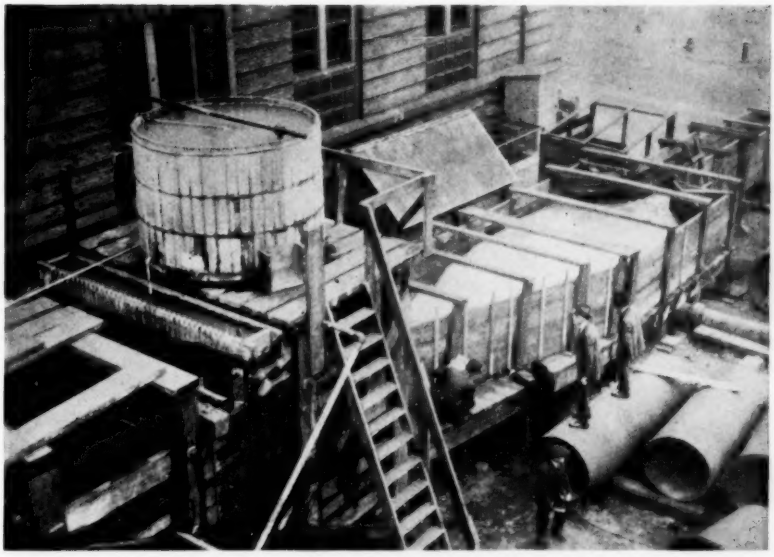

FIG. 4. TURBULENCE OF HYDRAULIC JUMP

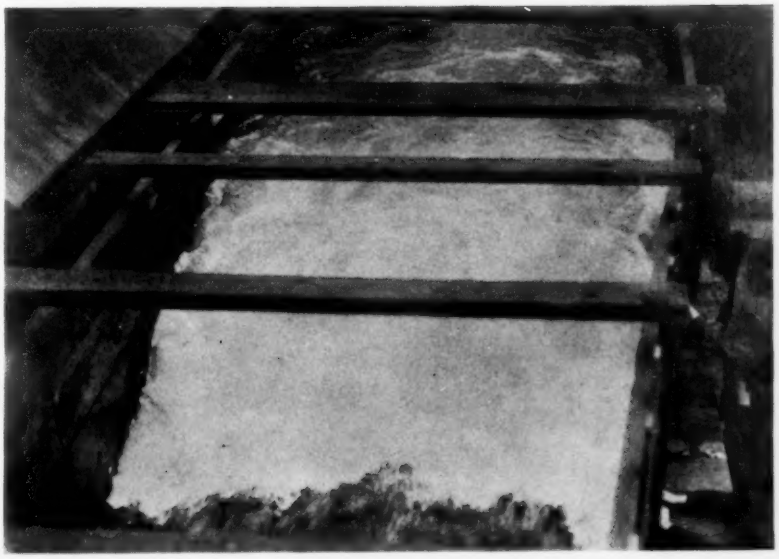

FIG. 5. CLOSE-UP VIEW OF TURBULENCE OF HYDRAULIC JUMP

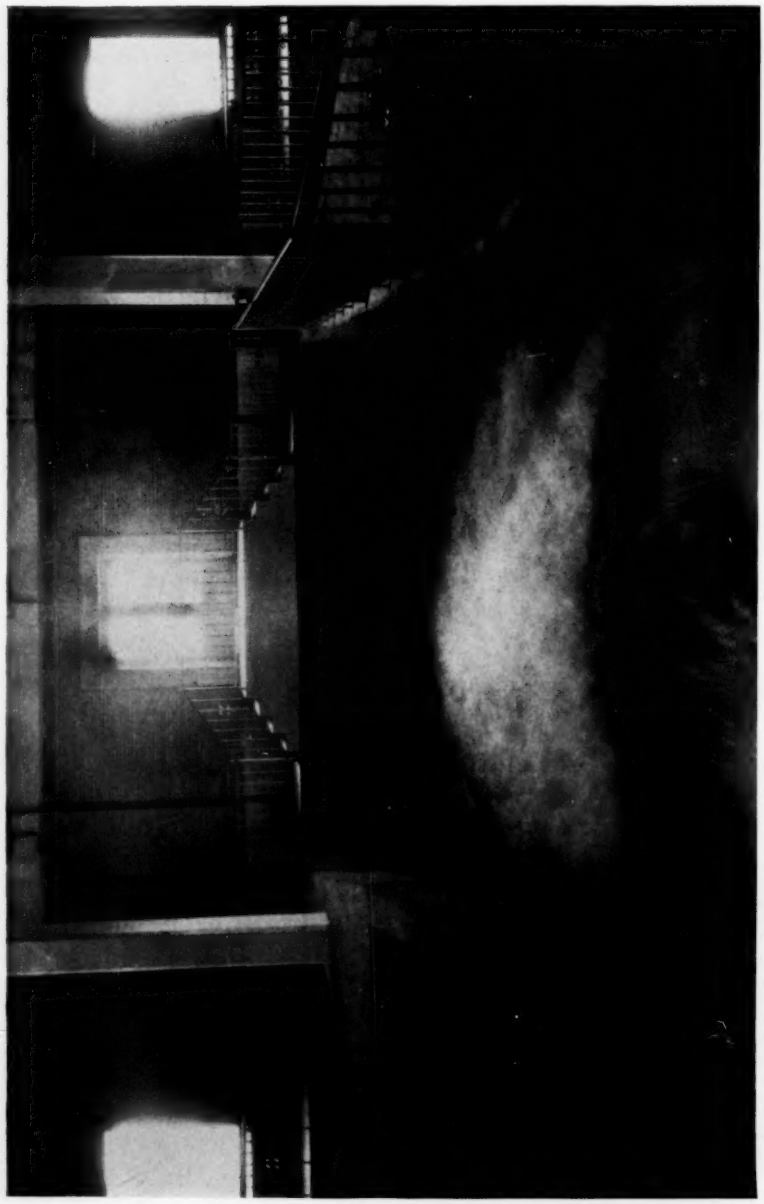

FIG. 6. ONE OF THE THREE 55 M.G.D. CAPACITY HYDRAULIC JUMPS AT CLEVELAND'S BALDWIN PLANT

The first set of hydraulic data was obtained from the flume as originally constructed. These observations consisted of gauge readings to determine the depths in the expanding flume, and in the water after the jump. It was especially desired to obtain the depth just before the jump and after a part of the experiments had been run and the data plotted, it was realized that the attempt to interpret the depths between the gauges within the vicinity of the jump was not satisfactory, and that other means of securing this information would have to be evolved. About this time,closer scrutiny was given to the appearance of the water in the expanding flume, and, as a result, the accuracy of the glass gauge measurements was questioned. The forked gauge apparatus was then devised and certain preliminary sets of readings taken with it. It was found, as was expected from appearances, that the depth of water varied at any given section across the expanding flume. There were apparently several conditions in this flume which accounted for the above mentioned variations in levels. These conditions were as follows:

1. Slight inequalities in the flooring at any given cross section due to the planking having been laid at right angles to the line of flow of the water.
2. Increased friction at the outer edges of the flowing stream due to the sides of the expanding flume.
3. Vertical uprights, which were required for structural reasons, in the stilling chamber up stream from the entrance to this flume, and which caused eddies, and
4. A sharp entrance to the throat of the flume.

All of these conditions could either be entirely obviated or minimized in any permanent structure. In the experimental flume, however, the first three conditions could not be changed, but the fourth was easily remedied and the change to the curved approach was made. The inability to make these changes in the experimental flume did not appreciably affect the results obtained, as we were enabled to take a sufficient number of readings of depths of water so that the average results were extremely accurate.

The exit end of the flume was wider than the flume connected to it used to convey the water to the lake, and therefore produced eddies at this point. This resulted in a somewhat greater depth of water here than was desirable, and it was in some measure reduced by the widening of the conveying flume to the full width of the exit end of the hydraulic jump flume and gradually reducing it, in a distance of

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about 22 feet, to the original width. This last change enabled a study to be made of flow conditions through a gradual contraction based on the theory of "maximum flow." This theory is exemplified by Lane in his "Flow of Water Through Contractions," published in the Transactions of the American Society of Civil Engineers, volume lxxxiii. According to Lane, this theory is applicable to a channel with a level floor only. However, with such small differences of floor elevations as existed, by utilizing Bernouilli's Theorem to take these differences into consideration, it was found practically to apply to the case in hand.

Up to this time in our experiments, no satisfactory way had been found to calculate the depth of water at the entrance to the expanding flume. With the installation of the gradual approach thereto, the experiments of Lane were again utilized, and on the basis of the "theory of maximum flow," the control depth at the entrance to the expanding flume was established. Another method of determining this depth was explained by Julian Hinds, in his article "The Hydraulic Jump and Critical Depth in the Design of Hydraulic Structures," published in the Engineering News Record of November 25, 1920.

From this time on, there were two main objectives, from the standpoint of the hydraulics of the jump; namely, (1) to determine how closely the computed and actual surface curves in the expanding flume checked, and (2) to locate the jump for any given depth of tail water.

The method of determining the surface curves, experimentally, was as follows: a dozen stations were located at intervals along the expanding section of the flume, being closer together near the entrance. These latter were required in order to study the changes which took place immediately after the water entered this flume. The vertical side of the movable bridge was placed at a given station at which it was desired to secure depth readings. The forked gauge was then held firmly against this side and gradually lowered in line with the 0.1 foot markings on its face until the points on the gauge just touched the water surface. Owing to the irregularity of the water, the object was to secure an average level and this was readily accomplished by watching the points as each one cut the surface of the swiftly moving water. When half of the points were in contact with the water surface, the gauge was read on line with the straight edge at the top of the bridge. The forked gauge was then moved

across the flume to another location, and a similar proceeding followed. This method was continued at four to six points in the width of the flume, depending on the station at which the bridge was set. This process was repeated until a total of from 20 to 25 readings had been taken at a given cross section. The location of the bridge was then accurately determined with reference to the entrance to the expanding flume, and was then moved to another station where similar measurements were secured with the forked gauge and the bridge similarly located with reference to the entrance to the expanding flume. The bridge was successively moved to each of the stations and the water surface measurements taken as before. After all surface measurements had been secured, the flow of water was cut off and measurements similarly made, at the various stations, to the floor of the flume. By differences the water depths were obtained. A special station was located in every case just before the jump. To avoid any differences in the deflection of the bridge, the same individual who took the water surface measurements always took the floor measurements also.

In order to compute the surface curve, the depth of water at the beginning of the slope of the expanding flume is secured from the formula:

$$Q = 3.09\, WH^{\frac{3}{2}}$$

which formula is derived from the theory of "maximum flow." In this formula,

Q = cubic feet per second.

W = width in feet at the entrance to the flume.

H = total energy head, namely, static plus velocity head.

The depth will, in every case, equal $\frac{2}{3}$ of the value of H. While the depth thus obtained is not strictly applicable to the point where the expanding flume begins to slope, practically this value can be used and the discrepancy soon disappears in the first few computations in the expanding flume itself. Having found a starting point from the above value, the remaining points of the surface curve can be obtained from the depths computed by means of Bernouilli's Theorem, which may be written:

$$\left(Y_1 + \frac{{v_1}^2}{2g}\right) - \left(Y_2 + \frac{{v_2}^2}{2g}\right) = \frac{l\, v^2}{c^2\, r}$$

in which Y_1 = elevation of water at the known section.

$\frac{v_1^2}{2g}$ = velocity head at the known section.

Y_2 = elevation of water at the section to be ascertained.

$\frac{v_2^2}{2g}$ = velocity head at the section to be ascertained.

l = distance between the sections measured along the slope.

v^2 = average of velocities at the two sections.

r = average of the hydraulic radii at the two sections.

c^2 = Kutter's coefficient based on the average "r."

In using this equation, it is necessary first to assume a depth at the section at which it is desired to secure a point on the surface curve. This depth once assumed, for any given quantity of water, the velocity head at the section can be determined, as well as the value of the friction loss as represented in the second part of the equation, namely, $\frac{lv^2}{c^2r}$. If, with the depth assumed, the equation does not balance, a new depth must be assumed and the process repeated until the two sides of the equation are equal. While this process may seem laborious, familiarity with the problem soon enables one to assume correct depths with remarkable facility. The agreement between the theoretical and actual surface curves is shown on figure 7.

Having obtained the surface curve in the manner just outlined, the next step, in carrying through the problem, requires the location at which the hydraulic jump takes place. For any given quantity of water, and any given type of flume, this location is a function of the depth of water at the foot of the slope. Theoretically, for any given depth of tail water, the location of the jump can be found by,

1. Starting with this depth and computing the tail water curve in a manner similar to that in which the surface curve was computed, with the exception that the second part of the equation may be omitted because the friction loss is so small as to be negligible, and

2. Finding the point at which this tail water curve intersects the locus of the jump, the latter being a curve which joins the various points designating the height to which the water would jump at the respective sections at which these points are located.

This height of jump, for any given section, can be obtained from the formula:

$$d_2 = \sqrt{\frac{2v_1^2 d_1}{g} + \frac{d_1^2}{4}} - \frac{d_1}{2}$$

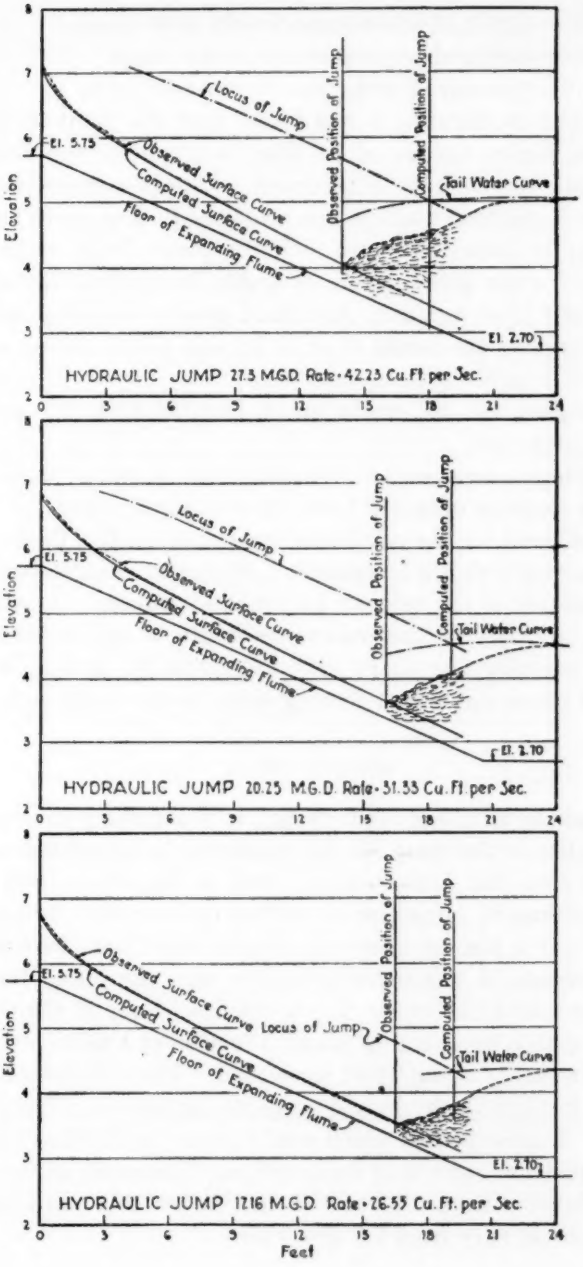
Elevation
Locus of Jump
Observed Position of Jump
Computed Position of Jump
El. 5.75
Observed Surface Curve
Computed Surface Curve
Floor of Expanding Flume
Tail Water Curve
El. 2.70
HYDRAULIC JUMP 27.3 M.G.D. Rate - 42.23 Cu. Ft. per Sec.
HYDRAULIC JUMP 20.25 M.G.D. Rate - 31.33 Cu. Ft. per Sec.
HYDRAULIC JUMP 17.16 M.G.D. Rate - 26.55 Cu. Ft. per Sec.
Feet

FIG. 7

in which d_2 = depth of water immediately after jump.
d_1 = depth of water just before the jump.
v_1 = velocity of water just before the jump.

From our experiments, it was found that the jump occurred, in every case, higher up the slope than is given by the theoretical location and, therefore, it is necessary to apply a correction factor before this theoretical position can be utilized. Inasmuch as the use of the jump in connection with filtration plant design requires, not its location for any given tail water depth, but rather the tail water depth for any fixed location, the actual process consists, in,

1. Determining the height of jump for any given section at which it is desired to have the jump take place,

2. Computing the tail water curve, starting with this particular height of jump; and

3. Applying a coefficient to the theoretical depth of water at the foot of the slope as obtained from the tail water curve.

This coefficient for the particular type of expanding flume used in our experiments is shown on figure 8. As may be seen, the coefficient is some function of the velocity before the jump and, therefore, the coefficient to apply to the theoretical depth of tail water may be found by entering the chart with this velocity, finding where it crosses the curve and then following down to the coefficient.

LOSS OF HEAD

For its use in filtration plant design, it is necessary to investigate the hydraulics of the jump for the maximum height of tail water as backed up from the highest water level in the coagulation basins, under conditions of minimum as well as of maximum flow through the flume. It is also necessary to keep in mind that, as a result of our experiments, it was found advisable that the jump should not be made to take place under any condition, closer to the throat of the flume than a minimum of about 3 feet or at a section having a velocity of less than about 9 feet per second. Under these conditions, the loss of head in the hydraulic jump mixing device is from 0.75 to 1.00 foot. This is the loss which would be produced when the water in the coagulation basin is at the overflow. Inasmuch as the normal operating level is from 0.75 to 1.00 foot below this point the total loss of head will vary from 1.5 to 2.0 feet.

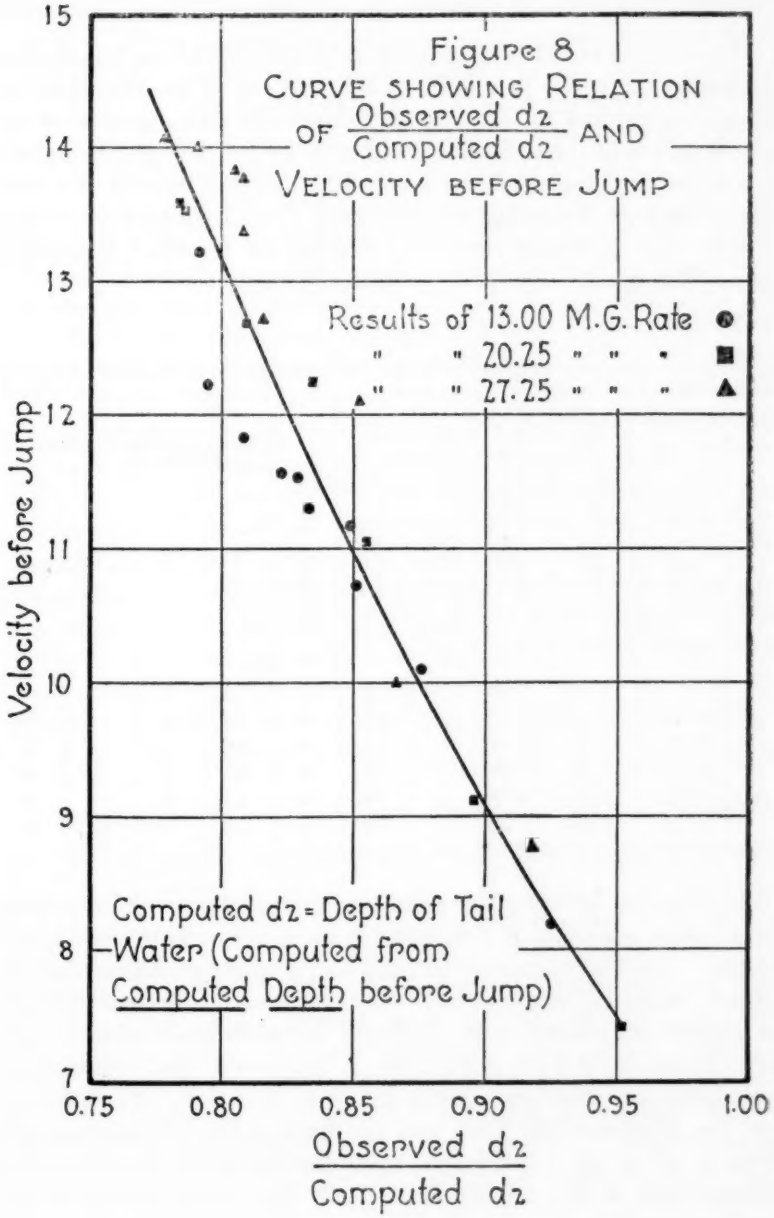
Figure 8
CURVE SHOWING RELATION
OF Observed d2 / Computed d2 AND
VELOCITY BEFORE JUMP
Results of 13.00 M.G. Rate
" " 20.25 " " "
" " 27.25 " " "
Computed d2 = Depth of Tail
Water (Computed from
Computed Depth before Jump)
Velocity before Jump
15
14
13
12
11
10
9
8
7
0.75
0.80
0.85
0.90
0.95
1.00
Observed d2 / Computed d2

FIG. 8

EFFECT OF HYDRAULIC JUMP ON REACTIONS OF ADDED CHEMICALS

The addition of solutions of sulphate of alumina, and of suspensions of lime to the water just prior to its entrance to the throat of the flume was studied in order to determine the thoroughness of the mixing action of the hydraulic jump, and the rapidity and completeness of the chemical reactions involved. The introduction of a solution of sulphate of alumina was first tried. After starting treatment, samples were collected every five minutes for a period of one-half hour. The results obtained are shown in table 1.

TABLE 1

Showing the completeness of the chemical reaction effected by the hydraulic jump

TEST NUMBER	RATE OF FLOW	DEPTH OF TAIL WATER	LOCATION OF JUMP FROM FLUME ENTRANCE	ALUMINUM SULPHATE ADDED	ALKALINITY OF RAW WATER	ALKALINITY OF TREATED WATER PARTS PER MILLION				
						Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
	m. g. d.	*feet*	*feet*	*grains per gallon*						
1	13	1.68	15.50	1	94	86	86	86	84	84
2	20.25	2.02	14.95	1	94	86	86	86	86	84
3	27.25	2.45	13.47	1	94	86	86	86	86	86
4	13	2.63	9.00	1	94	86	86	86	86	86
5	20.25	2.87	9.39	1	94	86	86	86	86	86
6	27.25	3.09	9.39	1	94	87	88	88	88	87

The reaction between the alum and the alkalinity of the water, like all ionic reactions, is completed in an immeasurably short space of time. The time of passage through the jump and pool immediately beyond, where the samples were taken, was about 30 seconds. As the theoretical reduction in alkalinity for each grain of alum per gallon added is 7.7 parts per million, it is apparent that the reaction is complete and that the mixing has been thorough. The rates of flow, the position of the jump, and the depth of the tail water are all given in the table to show that these variations do not affect the thoroughness of the mixing action, nor the completeness of the chemical reaction.

The application of a milk of lime to a water to effect a reduction

in its natural lime content offers as severe a test of the thoroughness of mixing and reaction velocities as is found in water purification problems. The milk of lime was applied to the water just before it entered the throat of the flume. Two samples of the treated water were taken beyond the jump at the entrance to the discharge flume every five minutes after starting to add the milk of lime. One of each pair of samples was tested immediately and then allowed to stand, while the other was shaken vigorously at frequent intervals for a period of one hour before being tested. Each pair of samples was tested at hourly intervals, thereafter, for several hours, and ,finally on the following morning. All samples were filtered before testing. The results are shown in detail in table 2.

It will be noted that, at the expiration of one, two, three or even twenty-four hours, there is no practical difference in the residual alkalinity of the pairs of samples of the treated water, no matter whether the samples had received additional agitation after passing through the jump or not. There was a gradual reduction in the total alkalinity of both samples of about ten parts per million, at the expiration of twenty-four hours, which is entirely normal, and which is obviously independent of the difference in the degree of agitation employed. This proves that the mixing afforded by the hydraulic jump had produced a thorough mingling of the water being treated with the applied milk of lime and that chemical reactions were completed in a normal manner.

RELATION OF MIXING ACTION OF HYDRAULIC JUMP TO COAGULATION

The efficiency of the hydraulic jump as a mixing device having been proved, the question arose as to what affect it had on the speed of formation of aluminum hydroxide floc, on the size of the floc, on its settling properties, and on its retentive capacity for bacteria when applied to a filter. The influence of additional agitation following the passage of the treated water through the jump was studied largely by means of bottle experiments and modifications of the large flume so that smaller quantities of water could be handled.

The formation of aluminum hydroxide by adding alum to an alkaline water has been intensively studied by many investigators during the past seven or eight years and many phases of the phenomena of coagulation are better understood than when the experiments summarized in this paper were undertaken in 1920 and 1921.

TABLE 2

Results of lime treatment at hydraulic jump flume¶

SAMPLE NUMBERS	DATE	RATE OF FLOW OF WATER M. G. PER DAY	GRAINS PER GALLON OF CaO	ALKALINITY OF RAW WATER		ALKALINITY OF TREATED WATER IMMEDIATELY AFTER SAMPLING				ALKALINITY OF TREATED WATER ONE HOUR AFTER SAMPLING				ALKALINITY OF TREATED WATER TWO HOURS AFTER SAMPLING				ALKALINITY OF TREATED WATER THREE HOURS AFTER SAMPLING				ALKALINITY OF TREATED WATER FOLLOWING DAY			
				Total	Mono.	Total	Bicarb.	Caust.	Mono.	Total	Bicarb.	Caust.	Mono.	Total	Bicarb.	Caust.	Mono.	Total	Bicarb.	Caust.	Mono.	Total	Bicarb.	Caust.	Mono.
*3	December 12, 1919	27.5	3.34	90	T	116	0	34	82	52	0	16	36	50	0	10	40	50	0	10	40	42	0	10	32
†3A	December 12, 1919	27.5	3.34	90	T					50	0	10	40	48	0	12	36	50	0	10	40	46	0	14	32
*7	December 30, 1919	27.5	3.26	90	0	134	0	2	132	54	6	0	48	46	10	0	36	42	10	0	32	40	12	0	28
†7A	December 30, 1919	27.5	3.26	90	0					50	0	10	40	44	4	0	40	44	4	0	40	40	0	0	40
*8	December 30, 1919	27.5	3.26	90	0	118	0	6	112	50	6	0	44	46	10	0	36	46	6	0	40	38	6	0	32
†8A	December 30, 1919	27.5	3.26	90	0					52	0	12	40	44	0	0	44	44	4	0	40	40	4	0	36
*9	December 30, 1919	27.5	3.26	90	0	118	0	18	100	50	6	0	44	48	4	0	44	44	8	0	36	40	8	0	32
†9A	December 30, 1919	27.5	3.26	90	0					48	0	8	40	46	0	6	40	44	4	0	40	36	12	0	24
*10	December 30, 1919	27.5	3.26	90	0	114	0	14	100	52	16	0	36	48	12	0	36	46	6	0	40	34	30	0	4
†10A	December 30, 1919	27.5	3.26	90	0					48	4	0	44	46	10	0	36	42	6	0	36	32	32	0	0
*11	December 31, 1919	27.5	3.17	92	T	148	0	20	128	48	8	0	40	46	6	0	40	46	2	0	44	42	0	2	40
†11A	December 31, 1919	27.5	3.17	92	T					50	0	2	48	42	2	0	40	50	0	2	48	46	0	14	32
*12	December 31, 1919	27.5	3.17	92	T	136	0	16	120	54	2	0	52	46	6	0	40	44	8	0	36	42	0	2	40
†12A	December 31, 1919	27.5	3.17	92	T					44	12	0	32	46	6	0	40	40	4	0	36	32	12	0	20
*13	December 31, 1919	27.5	3.17	92	T	142	0	2	140	46	10	0	36	40	12	0	28	40	24	0	16	40	0	0	40
†13A	December 31, 1919	27.5	3.17	92	T					50	2	0	48	44	4	0	40	40	4	0	36	38	2	0	36

*14	December 31, 1919	27.5	3.17	92	T	130	0	6	124	46	18	0	28	44	16	0	28	44	8	0	36	40	4	0	36
†14A	December 31, 1919	27.5	3.17	92	T					44	8	0	36	46	10	0	36	44	8	0	36	36	4	0	32
*15	January 7, 1920	29.5	3.87	94	T	116	4	0	112	56	0	12	44	42	6	0	36	52	0	0	52	50	0	6	44
†15A	January 7, 1920	29.5	3.87	94	T					54	0	6	48	46	2	0	44	48	4	0	44	40	0	4	36
*16	January 7, 1920	29.5	3.87	94	T	122	0	2	120	52	0	0	52	46	2	0	44	48	4	0	44	36	4	0	32
†16A	January 7, 1920	29.5	3.87	94	T					50	0	2	48	44	8	0	36	46	6	0	40	40	0	8	32
*17	January 7, 1920	29.5	3.87	94	T	116	0	8	108	56	0	8	48	46	10	0	36	54	2	0	52	44	0	4	40
†17A	January 7, 1920	29.5	3.87	94	T					52	0	4	48	38	10	0	28	54	0	2	52	38	2	0	36
*18	January 7, 1920	29.5	3.87	94	T	126	0	10	116	50	2	0	48	44	4	0	40	50	2	0	48	36	4	0	32
†18A	January 7, 1920	29.5	3.87	94	T					44	4	0	40	44	8	0	36	50	0	6	44	40	0	8	32
*19	January 13, 1920	27.5	2.45	94	T	122	10	0	112	54	10	0	44	48	16	0	32	50	14	0	36	42	10	0	32
†19A	January 13, 1920	27.5	2.45	94	T					50	22	0	28	48	20	0	28	48	20	0	28	42	10	0	32
*20	January 13, 1920	27.5	2.45	94	T	120	12	0	108	56	20	0	36	56	20	0	36	52	20	0	32	42	14	0	28
†20A	January 13, 1920	27.5	2.45	94	T					52	20	0	32	48	20	0	28	48	20	0	28	42	18	0	24
*21	January 13, 1920	27.5	2.45	94	T	120	12	0	108	56	20	0	36	54	22	0	32	50	22	0	28	44	16	0	28
†21A	January 13, 1920	27.5	2.45	94	T					50	14	0	36	50	22	0	28	48	20	0	28	42	14	0	28
*22	January 13, 1920	27.5	2.45	94	T	126	6	0	120	56	20	0	36	52	24	0	28	50	26	0	24	42	22	0	20
†22A	January 13, 1930	27.5	2.45	94	T					54	22	0	32	52	28	0	24	50	26	0	24	42	22	0	20
‡				92	T	125	0	3	122	52	0	1	51	47	1	0	46	47	1	0	46	41	7	0	34
§				92	T					50	4	0	46	46	2	0	44	46	5	0	41	40	3	0	37

* All samples without a letter show results of mixing effect of Jump only.
† All other samples were given one hour additional mixing.
‡ Average of samples marked thus (*)
§ Average of samples marked thus (†)
¶ All results in parts per million.

It is now known that the controlling factor of coagulation is the hydrogen-ion concentration of the water, and that the influence of dissolved salts and organic matter may materially affect this concentration.

Our observations were confined to the comparison of samples of Lake Erie water treated in different ways in order to study the effect of varying degrees of agitation on the size of the floc and on the length of time required for it to form. Obviously, no good measure of floc formation was or is now available, and much depends on personal judgments. The general conclusions reached from a large number of experiments are, however, as follows:

1. Violent agitation to produce thorough and rapid mixing of the applied chemical and the water to be treated is the first requisite for chemical reaction preparatory to proper flocculation. This effect is produced by the hydraulic jump.

2. The time required to produce such mixing is probably less than 30 seconds or the time required for the passage of the water through the jump and the pool beyond.

3. Continued violent agitation following the mixing action of the jump is detrimental to floc formation.

4. Gentle agitation produced by a velocity of flow from 0.75 to 1.00 foot per second hastens floc formation and produces a good aggregation of the finely divided particles in about 5 to 6 minutes. Velocities below these figures require a longer time for floc formation; velocities above these figures may hinder floc formation if continued too long.

5. Slightly baffled channels so designed with relation to the flow as to produce the above velocities for the period mentioned above will provide the requisite conditions for rapid flocculation.

6. Bacterial removals by sand filtration of water mixed by the hydraulic jump and passed through a settling chamber, prior to filtration, showed equally as good results as the same water mixed in a baffled mixing chamber and settled.

The studies made by the writers were carried on with Lake Erie water, which is one which has practically no color, and very low turbidity. Its alkalinity is rather high and consequently its hydrogen-ion concentration (pH. 7.8 to 8.1) low. The amounts of alum used were in most cases 1 grain per gallon or less, and, in consequence, the hydrogen-ion concentration was raised but little and certainly

was very far from the optimum concentration for the rapid formation of aluminum hydroxide floc which later investigators found desirable. The use of the hydraulic jump on other types of water has, usually, proved the soundness of the deductions drawn from our experiments. It may be that some modification of time and velocity factors, following the passage of turbid or softened waters through the jump, will be required in some cases; but, in general, it is believed that these variations will not be markedly different from those found in this investigation.

GENERAL CONCLUSIONS

The general conclusions as a result of this work may be summarized as follows:

1. The hydraulic jump is an extremely effective means for mixing chemicals with water to be purified.

2. The mixing effect is produced with great rapidity and with remarkable thoroughness.

3. The chemical reactions cannot take place until the chemical or chemicals are in solution and are diffused throughout the water to be treated, which latter is so many times larger in volume than the reagent solutions being applied, that the value of a rapid and thorough method of mixing is obvious.

4. The energy relations of the hydraulic jump have been studied by several investigators and the principles involved are sufficiently well understood so that it is possible to design and construct a flume in which the "jump" may be produced and controlled within comparatively narrow limits.

5. The loss of head through such a "jump" may be made as low, if not lower, than is produced in any of the conventional, baffled, mixing chambers, hence its practicability and economy from the hydraulic standpoint.

6. The structure in which the jump may be produced is simple, requiring comparatively little space and a small amount of material for its construction. On this score its cost is far less than that of the conventional, baffled mixing chamber.

7. The jump conveniently lends itself, after thorough mixing of the chemicals with the water, to any character of structure desired beyond the "jump" to facilitate coagulation and sedimentation.

DISCUSSION

WM. GORE:[5] This paper gives an interesting and valuable account of experiments relating to an important hydraulic principle and of its application to the art of water purification. The authors are to be highly complimented on the excellence of their work which forms a valuable addition both to the science of hydraulics and to the art of water purification.

The hydraulic jump is essentially an open sloping channel terminating in a still or dead water basin. The high velocities generated in the rapid fall of any liquid passing down the channel is dissipated by shock in the still water basin. The principle involved is encountered in nature in the tidal bore and the device has been used largely in reservoir overflows and drop discharges in sewers. While the present paper gives detailed studies of the hydraulic principle it shows it to be an excellent mixing device by reason of the turmoil which takes place in the so called still water basin.

It should however be pointed out that any device which produces shock in a moving body of water such as an obstruction in a water main by a partially closed valve or orifice is or can be made equally or almost equally as good a mixing device as the hydraulic jump, the difference if any being in the aeration in the jump, but the potential energy is dissipated by shock or turbulence in the same way in both cases. The obstructed flow in a pipe is well known as a mixing device in the art of water purification.

In places where a centrifugal pump is in use as a lifting device at the purification plant it would appear to afford the logical means for mixing the chemicals with the water, particularly if the chemicals are added at the eye or suction inlet of the pump. A centrifugal pump lifting water 20 feet with an efficiency of 80 per cent dissipates as much energy by turmoil in the water as in an hydraulic jump with a drop of 4 feet. This turmoil can and is being successfully used for mixing purposes in the art of water purification. The operation of mixing as in the case of the hydraulic jump takes place so quickly that there is little time for chemical changes and local coagulation to take place previous to complete mixing.

ALMON L. FALES:[6] The speaker would like to say a word of appreciation of the work of Levy and Ellms in developing the hydraulic

[5] Of Gore, Nasmith and Storrie, Toronto, Can.
[6] Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

jump as a mixing device. It is certainly an effective device for this purpose.

Along the line of what Mr. Gore has said I would like to state that we have found the centrifugal pump to be an excellent mixing device when the coagulant is added close to the pump suction.

In several cases where it has been necessary to pump industrial wastes which required treatment with alum, we have introduced the alum solution at the suction of the pump with very satisfactory results. We have also had experience in pumping wastes where the alum had been applied some distance ahead of the pump, so that the floc had formed before pumping, and in such cases the floc was completely broken up by the centrifugal pump.

I have in mind one instance where tannery wastes treated with alum, had flocculated to such an extent that, if the wastes were allowed to stand and settle, they would become very clear, whereas after pumping the treated wastes with a centrifugal pump there was no indication that a coagulant had been added. The wastes were returned to their original turbid, colloidal condition. It is very important to introduce the alum close to the suction of the pump, so as to get the mixing immediately and the flocculation afterwards.

J. W. Ellms:[4] The chemicals used in water purification processes are applied as a solution or as a suspension. The volume of the liquid in which they are dissolved or suspended is relatively very small compared with the volume of the water to which they are added. The need for a thorough mixing of the two liquids is obvious, since no chemical reactions, and the physical changes resulting therefrom, can take place unless there is a commingling of the two liquids. The larger the volume of the water to be treated, the more difficult it becomes to bring about a thorough and rapid mixing. In the earlier and smaller plants that were built probably little attention was given to this feature of the process; but when the building of larger plants became more common, it was found necessary to provide for a more complete incorporation of the chemicals with the water. This explains, it is believed, how mixing channels or chambers became a common feature of design of water filtration and softening plants.

In order to prevent sedimentation in the channels, it was necessary to give the water a velocity that would insure the carriage of all the sediment through the channels into the settling basins. To effect

this result long and narrow channels were constructed, and to prevent a possible stratification and to insure a positive mixing of the top and bottom layers of water over and under baffles were introduced into the design. The final result was a costly and cumbersome structure.

The hydraulic jump mixing flume was designed to overcome the objectionable features of the conventional around-the-end and over and under baffled mixing chambers. It accomplishes the purpose for which it was designed as explained in this paper. It mixes within less than one minute a very small volume of chemical solution with the relatively very large volume of water being treated; it produces a uniform diffusion of the chemical solution; it thoroughly aerates the water as it passes through the jump; it is extremely flexible in adapting itself to variations in the rate of flow of the water; it uses no more head, if as much, than is commonly required in the usual mixing chamber; and it can be produced in a small and comparatively inexpensive structure. It is being successfully used in the purification of colored, turbid and clear waters.

The hydraulic jump flume is a device for mixing. It is not a panacea for those errors of design which give rise to improper periods of sedimentation or coagulation; or for those obscure problems, such as imperfect flocculation and its relation to hydrogen-ion concentration, to the buffer effects of salts or to the varying characteristics of the colloidal state of the suspended matter that may be present in the water. The solution of these difficulties must be sought for elsewhere than in the simple and necessary intermingling of the reacting chemicals and the water being treated.

It is quite true, as the previous speakers have pointed out, that rapid mixing may be effected by discharging the chemical solution into the raw water pumps. However, the rapidly formed floc must be subjected to such violent treatment either within the pump itself (especially where centrifugal pumps are used), or in the force mains beyond the pump, that it is liable to be badly broken up. Once the floc is torn to pieces, its value as a coagulating agent is practically lost. That such a method of mixing has not been more generally used would seem to indicate that difficulties of the nature of those named above were the cause, and that if, as claimed by the previous speaker, it has ever been successful there must have been conditions peculiar to those particular installations or to the type of water being treated, which made it a practical method.

INCREASING THE WATER SUPPLY OF WASHINGTON, D. C.[1]

By J. E. Curtis[2]

That the city of Washington is increasing its water supply is not nearly so remarkable as that it has not increased it since the present supply was built. A brief mention of the present system, because of its intimate relation with the new system now being constructed, may be of interest.

Back in 1859 the first water was turned into the conduit to supply a population of 58,000. The estimated daily capacity of the aqueduct was 67½ million gallons or sufficient to give every being in the city a quantity of water that even some of our moderns, accustomed to waste it, could not possibly have consumed. The vision of the engineers who built this system is further emphasized by the fact that, at the time of its completion, the 9-foot diameter supply conduit was reduced to a 12-inch diameter main to supply the entire city, and the same conduit now supplies a population increased over 800 per cent.

The present system consists of a dam across the Potomac river, a circular masonry conduit 9 feet in diameter and 12 miles long having a fall of 9 inches to the mile, 3 storage and sedimentation reservoirs, a tunnel 4 miles long under the city, a pumping station, a slow sand filtration plant of 29 one-acre beds and a clear water reservoir. In addition there are the distribution mains, pumping stations and high service reservoirs. The water supply and purification works are vested in the Chief of Engineers, United States Army, while the distribution is vested in the city government.

After various projects for new supplies were investigated Congress, in 1921, appropriated funds to begin the construction of an increased water supply. This project takes its supply from the Potomac river through a new intake gate house about 100 feet above the present intake at Great Falls, Md.

[1] Presented before the Buffalo Convention, June 8, 1926.

[2] Superintendent, Washington Aqueduct, Washington, D. C.

The first 2800 feet of the new conduit are in tunnel to a point where it approaches the old conduit. Here a drop shaft, an under crossing of the old conduit, and a rise shaft form the beginning of about 8 miles of conduit paralleling, at about 30 feet center to center, the present conduit. Since the old conduit was built as nearly as practicable to a contour it follows that both it and the new one consist of a large number of curves and tangents. The conduit is horse shoe shaped, 10 feet wide by 10 feet high, with a waterway of 79 square feet. It is unreinforced for the greater part of its length, but there are several short sections where it was impossible to place a backfill on the down hill side and these sections have been heavily reinforced. The conduit was not designed for, or will it operate under, a head, but to increase its strength it is covered with about 3 feet of backfill over the crown of the arch. At Cabin John Creek where the old conduit crossed on an arch bridge, for many years the longest masonry arch in the world, having a span of 220 feet, the new conduit is built as an inverted siphon following the steep slopes on either side and crossing the stream on piers. This crossing was made sufficiently strong to resist displacement should the stream become clogged between piers and overflow the siphon. The siphon is circular in section and consists of a riveted steel pipe 10 feet in diameter and $\frac{3}{8}$ inch thick surrounded on the outside with 12 inches of concrete and lined inside with 6 inches of concrete. The pipe is made from plates 7 feet wide and was fabricated and shipped in 35-foot lengths. After the entire steel pipe was erected it was bulkheaded at each end, filled with water under slightly more than the working head and the outside concrete poured. After this concrete had set the siphon was drained and the inside lining placed by means of forming. The filling with water was done to cause the pipe to take the shape it would assume when in operation and consequently not set up unusual strains in the concrete envelope. The 6-inch thickness of the concrete lining is more than is necessary for the protection of the steel pipe, but assures ample protection where a flattening of the pipe might possibly have lessened the thickness of the lining caused by the use of regular cylindrical concrete forms. At approximately equal intervals cross connection gate houses have been provided between the new and the old conduits so that sections of either may be drained for inspection or repairs.

For construction the conduit was divided into 4 sections; the intake gate house and tunnel at Great Falls; and 3 cut and cover sections, the last section including the Cabin John Siphon, the gate

house at Dalecarlia reservoir, and a tunnel 800 feet long near the outlet. Construction was done by contract and the M. A. Long Company of Baltimore, Md. was the contractor for the first section and the Arundel Corporation of Baltimore, Md. was the contractor for the remaining sections. For the cut and cover sections the contractors used steam shovels for trenching and cast the excavation along the trench where it was later backfilled by the use of steam shovels. A considerable amount of excavation was hauled by trucks from the shovels and deposited over the finished concrete. The invert was placed in alternate 15-foot sections and the arch poured in sections varying from 50 to 100 feet. Portable concrete mixers were used along the edge of the trench and poured concrete directly into the arch forms on either side of the conduit in approximately level layers. The arch forming was of steel and was moved ahead on rails. All material was delivered from Washington by trucks.

The unit prices for several of the major items of the conduit were as follows:

Division No. 1

Ordinary excavation, including backfill	$1.55 cu. yd.
Rock excavation in open cut	2.80 cu. yd.
Concrete in conduit	16.50 cu. yd.

Division No. 2

Ordinary excavation, including backfill	$0.75 cu. yd.
Rock excavation in open cut	1.45 cu. yd.
Furnishing and placing sheeting and bracing	0.025 ft. b. m.
Concrete in conduit	14.10 cu. yd.

Division No. 3

Furnishing and placing steel pipe for siphon	$0.062 per lb.
Furnishing and placing reinforcing steel	0.05 per lb.
Ordinary excavation, including backfill	0.75 cu. yd.
Rock excavation in open cut	1.45 cu. yd.
Concrete in conduit	13.31 cu. yd.

The water from both the old and the new conduits empties into Dalecarlia reservoir, having an area of about 50 acres. Near the outlet of this reservoir there is being constructed an 80 million gallon per day rapid sand filtration plant, pumping station and hydroelectric power plant. For about twenty years the combined capacity of the 2 conduits will furnish an excess of water sufficient for power to pump the filtered water to the high sections of the city. For this supply 2 high service reservoirs of concrete with groined arch roofs,

having a capacity of 15 million gallons each, have been built at different elevations, and concrete pressure mains laid with diameters of 36, 42 and 48 inches. Only this brief mention of the filtration plant is made since a complete description will be presented in another paper by P. O. Macqueen, Assistant Engineer, in charge of this portion of the work.

The entire project for an increased water supply is about 60 per cent completed and will cost in its entirety approximately $9,000,000.

MOSQUITO CONTROL IN RELATION TO IMPOUNDED WATER SUPPLY[1]

By J. A. Le Prince[2]

In recent years there has come about a decided change in the industrial and farm labor situations which has an important influence on the relation of malaria to that which the engineer may construct.

During the last two years some of the cotton crops of the Southwest and even as far north as Memphis are being gathered by labor from Mexico. Throughout the Mississippi Delta the negro farm tenant labor is constantly changing from one plantation to another, so that 75 per cent of the negro families move once a year.

Well conducted investigations, carried out on a large scale, indicate that it is not economically practical to control and effectively reduce malaria with a constantly shifting farm tenant population in our country by the use of quinine administration alone. Several such attempts have been made under proper medical supervision, but results are invariably unsatisfactory. Any large area which might be made free from malaria cases this year will be repopulated with new cases from elsewhere next year.

The study of this condition has caused many experienced malariologists to realize fully that malaria elimination is an engineering project as well as a medical problem. That brings up the question: What is being done by the engineering profession toward the elimination of malaria? The answer is that those who know the facts in the case have not had the necessary opportunity to place the situation before the engineering profession effectively, and that engineers as well as others have in many instances been building malaria into communities over a large section of our country without knowing they were doing so.

In connection with the impounding of waters, let me cite an instance: Last summer I was called on by a state board of health to

[1] Presented before the Buffalo Convention, June 11, 1926.

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look over a lake less than two years old. The town had impounded a stream to furnish a drinking water supply and electric light. The project was a good one and the financial results a success. However, soon after the water was impounded an outbreak of malaria appeared at the homes of the farming population living within less than a mile from the lake, and at the time of my visit a year later most of the families were down with chills and fever and expecting the city to pay them liberally for the suffering and loss of working time it had caused.

The city officials claim they had no idea the project would cause such havoc; and the people affected say neither did they; but the town must pay.

It is evident that the engineer in charge in his preliminary surveys and estimates carefully considered all phases of the project except the malaria hazard; and that he knew nothing whatsoever about that. This is merely one illustration of what malariologists mean when they speak of building malaria in.

Before we knew what malaria was and how to prevent it, our profession placed culvert bottoms too high to allow the territory above to be effectively drained so far as malaria is concerned.

We constructed a series of borrow pits along the railroads leading to villages and towns, which increased the supply of malaria mosquitoes; and then to cap the climax we often allowed the contractors to draw their labor from communities having high malaria rates where jobs for the laboring man are harder to find.

Thus, unconsciously, the engineer was bringing increased malaria prevalence to town or village along with increased transportation facilities.

I recently had the pleasure of giving a short talk at the North Carolina Section of the American Water Works Association on the "Relation of Storage Water Supply Lakes to Malaria," which was published in THE JOURNAL (Vol. 15, No. 1, January, 1926), to which I desire to invite your attention.

During the month in which the article appeared an inquiry was sent by a prominent consulting engineer to the United States Public Health Service asking for some additional information regarding the city water supply lake then being constructed under his direction. If the engineer in the Tennessee case cited had called on his State Board of Health, the epidemic of malaria could have been prevented. The United States Public Health Service has investigated and studied

the problems of malaria in relation to impounding of water for a period of ten years and is frequently called upon to assist state health departments in that connection.

For those of you who are interested in this subject, or who some day may be decidedly so when engaged in projects in this country or others, where you must either solve your malaria problem or wreck your project or reputation, I desire to invite attention to the various Governmental reprints of the United States Public Health Service reports giving the information that engineers require and particularly to articles on impounded water in the Proceedings of Malaria Field Workers, published by the same Bureau. You can send for a printed list of such information and send later for any particular reprint, etc., you desire. Some of our American engineers working south of the Rio Grande where losses of labor efficiency and labor turnover amount to many thousands of dollars have failed to inform themselves relative to malaria control measures, and consequently have their working forces "riddled with malaria." Dr. L. O. Howard, the "father of mosquito control in the United States," estimated several years ago that malaria costs in our country amount to a hundred million dollars a year.

For those of you who desire to know in a few words how to prevent a body of impounded water from being a potential malaria menace the following information is submitted.

Malaria is conveyed from man to man by certain species of one family of mosquitoes and in no other way. This kind of mosquito is called the Anopheles. Nearly all of them have spotted or mottled wings, while others have clear wings. In our country the malaria mosquito responsible for nearly all of our malaria has four distinct dark spots on the wing and like the other malaria mosquito is said to "stand on its head." To distinguish a malaria mosquito from other kinds you observe its resting position. Most insects and mosquitoes rest with their bodies approximately parallel to the surface they are resting on. The malaria mosquito (Anopheles) does not. To the eye it looks like a brad, or small splinter, driven into the resting surface at an angle of 45° to the surface rested upon.

The malaria mosquito generally deposits its eggs in water where there is floating debris, aquatic vegetation, grasses, or other protection for its young. Two or three days after eggs are laid, small wiggle tails (mosquito larvae) come from the eggs and rest, live, and feed at the water surface. Larvae of most of the other mosquitoes are

bottom feeders, hence the name wiggletails—they wiggle down, get food and float or wiggle back to the surface to get air.

We see then that both larvae and adults of the malaria conveying mosquito differ in resting position from other kinds of mosquitoes and are easy to distinguish. As the negro said, "De wiggletails of de malaria is high top floaters and de others go up and down."

Small fish (and particularly the surface feeding minnows) are nature's best enemy of the mosquito. The surface feeding Anopheles larvae are the preferential food of Gambusia, the small surface feeding minnow that gives direct birth to its young. This minnow thrives in nature, from Virginia and Central Illinois southwards.

As soon as you begin to impound water numerous small rafts of floatage, consisting of logs, small sticks, leaves, and other light debris, collect on the water surface. The Anopheles lays her eggs in this floating debris, and it is difficult for fish and other aquatic enemies to find them. Within an inch of the small wiggletail may be a dozen or ten dozen particles of debris that from below may look exactly like wiggletails. When the Anopheles larvae see their enemy approaching they generally remain perfectly quiet so that they may appear to be a small particle of floatage.

For these reasons *we consider floatage our main problem in mosquito control of impounded water projects.* We find that the wind has a way of driving it into inlets; and also that it collects at the upper ends of inlets to where it is washed down the streams from above. For those reasons most malaria mosquito larvae, when they occur in impounded waters, are to be found in the upper third or upper quarter of the inlets, bights, or indentations. Wave action where sufficiently constant and active drowns mosquito larvae. On one lake in central Alabama where a certain aquatic growth favors Anopheles production, a speed launch is used to eliminate mosquito larvae. Three launches have been worn out in this successful mosquito control work in the past ten mosquito seasons on this lake. The problem there was to eliminate malaria or close down a large coal mine.

High water and strong wave and wind action strand floatage along shore. This is one of nature's control methods. Let the engineer use it. Where we can, let us use flash boards and hold the water 2 feet, or 3 feet, if it is practical, above summer high water level. The winter winds take nearly all logs, sticks and floatage ashore for us. As soon as the mosquito season comes on we lower the water level a

foot. All the flooded vegetation has been killed and the lowered water level gives us a clean shoreline where the fish and other aquatic enemies can get the last mosquito larva. The malaria mosquito generally does not lay her eggs along lakeshores in the absence of floatage or shoreline vegetation, as she knows they will be promptly gobbled up or killed.

If we have a constant level pond with vegetation in water at the edges, we often find the mosquito larvae at the water surface hiding in or protected by the vegetation. When we lower the water the larvae follow it and are exposed to fish, and any remaining behind are dried up and die. If before the malaria season is ended vegetation again protects mosquito larvae along the pond edge and larvae occur in it, then we can again lower the pond surface a foot—and thus remove the larvae to where the fish are waiting for them.

If we impound water during the mosquito season and thus cause much floatage to collect on the water surface at that time, conditions will probably be made decidedly favorable for maximum mosquito production.

If in addition the new lake is stocked with bass or other game fish which destroy the top feeding minnows and other kinds of fish and aquatic insects that prey on mosquito larvae, we should expect to increase the Anopheles supply. Instances of this nature have taken place with serious results.

In some recent engineering construction projects adequate precautions have been taken against the introduction of malaria carriers when new laborers were brought in.

Generally speaking, lakes with relatively clean shore lines, that are free of floatage do not produce Anopheles.

In some instances fish are able to prevent Anopheles production even in the presence of considerable aquatic vegetation. However with certain aquatic plants and particularly when algae (spirogyra) are present with vegetation and floatage it may happen that the fish, even when numerous, will be unable to prevent Anopheles production.

In one instance (a lake near Hartsville, S. C.) the lake surface was matted with pond lilies, water-shield, other aquatic plants and some spirogyra. The fish (Gambusia) were exceedingly numerous, and throughout an entire season Anopheles larvae were always devoured by Gambusia before reaching maturity. This was very exceptional.

To prevent production of Anopheles in lakes:

a. When practical hold the water about two feet or more higher in the non mosquito season than in summer. Use flashboards, gates or other regulating devices for water level control purposes. The object of lowering the water level is to strand floatage along the shoreline, to bring any mosquito larvae present away from vegetation protection and leave them at a clean shore edge where their enemies can get them. Also to make the shore line unattractive to mosquitoes.

b. Keep the water surface free of floatage.

c. When new aquatic plants appear, remove the first that come up. Cattails and some other plants multiply rapidly and are expensive to remove if given a good start.

d. In clearing brush, trees, etc., from the lake bed, make a good clean job of clearing in the upper third of all lake inlets. Wave protected inlets may become important breeding places of malaria conveying mosquitoes.

e. As mosquito production is generally at its maximum during the first three years after the water is impounded, weekly inspection of the lake may then be necessary.

f. In some instances collection and removal of floatage may be facilitated by using booms made of logs or saplings.

g. It is decidedly advisable to start fish hatcheries (for mosquito destroying fish) several years before water is impounded. It is not possible to overstock the lake with mosquito destroying fish.

h. To destroy mosquito larvae we apply oil or larvacides.

It should be mentioned that these malaria conveying mosquitoes are night feeders and do not become infected until more than a week after they have bitten a malaria carrier. Also that after taking a blood meal they nearly always rest on the bedroom walls for a day before leaving the building. By a systematic daily destruction of the engorged Anopheles in the bunk houses we can economically reduce the spread of malaria among our working forces.

Full details showing the value of this procedure are given in the August, 1920, number of "The Military Surgeon."

In order to prevent the spread of malaria near the lake above the Mitchell Dam on the Coosa River near Birmingham, Alabama, adequate precautionary measures were taken during the construction period, and as a result the malaria sick rate in the territory adjacent to the lake has been lower since the water was impounded than in previous years. Evidently, then, engineers can build malaria out of existence.

WATER SUPPLIES OF FLORIDA[1]

By E. L. Filby[2]

Florida and Florida water supplies have been bound together inseparably since Ponce de Leon in 1512, looking for the fabled "Fountain of Youth," discovered the land of flowers—Florida. In 1925, the year of the great migration to Florida, one could hear comments on Florida water in every hotel and tourist camp. Auto pilgrims from the north and west often brought water along or purchased bottled waters of brands familiar back home. Drink Florida water? No, sir! Even moving picture troupes taking scenes had bottled water for all members of the company, for the city water where they were living was not to be thus used—although it has been for years used by the railroads for drinking purposes. One heard marvelous tales. Florida's Fountain of Youth was discovered in many parts of the State. Her 30,000 odd lakes from Okeechobee, the largest fresh water lake entirely within the United States, thirty miles one way and forty the other, down to the smallest newly created subdivision lake together with hundreds of gushing, boiling springs, all became famous over night either for health giving qualities, fishing or beauty. With an average rainfall of 53 inches at Jacksonville, 59 inches at Jupiter, near West Palm Beach, 54 inches at Tampa and 56 at Pensacola, one can realize that Florida receives her share of J. Pluvius' product. A state average of 52 inches is a fair one. By virtue of water, Florida water, land values doubled and trebled. But enough—one of the state's big assets is her water supplies, her lakes, her springs and her coasts.

Water supply, geography and geology are all so inter-related that one must really and literally subdivide the state—not into business lots, but into certain districts familiar to all of you by name. Let us tour Florida on an inspection trip of her public water supplies, springs, etc. We will start as a traveler from Missouri—we enter Florida at her western portal—Pensacola. This city swears by its municipally-

[1] Presented before the Buffalo Convention, June 9, 1926.

[2] Chief Engineer, State Board of Health, Jacksonville, Fla.

owned and operated water supply, proudly advertising on cards that Pensacola water is 100 per cent pure. The supply is from driven wells about 150 feet deep sunk into a water bearing sand geologically of the Pleistocene age. The supply is very soft having a hardness of only 12 parts per million and a total solids content of 41 parts per million. Chemically pretty near 100 per cent pure; they use it in automobile and boat batteries without distillation! No treatment is afforded the water. We will head east on the road to Jacksonville with possibly a few side trips.

Bonifay a municipal supply, drilled 450 feet into what geologists term Vicksburgian limestone—the most reliable source of water in all Florida. Geologically all rocks in Florida are sedimentary and were for the most part deposited beneath the ocean, therefore, containing salt sea water. The principal source of springs and deep well supplies is the soft porous Vicksburgian limestone. Large underground channels must exist, but the rock ordinarily is honeycombed with small pores and passageways. The Vicksburg limestone is often subdivided into three formations, Ocala limestone, Peninsular limestone and Marianna limestone. Suffice to say practically all deep seated supplies of any importance or quantity are taken from the Vicksburg group of limestone. Bonifay water illustrates the fact that proceeding east we are getting into deeper wells and harder waters. Depth is now 450 feet and hardness 120 parts per million and total solids 140 parts per million.

At New Valparaiso the free flowing water with a temperature of 76°F. all year around is the basis of a new sanitarium. All this country west of Apalachicola River is rolling sandy clay hills to flat pine bottoms near the coast. It is purely agriculture and timber country.

A line from Apalachicola, the famous oyster center, east to St. Augustine, will include our next subdivision. Tallahassee, capital city, municipally owned plant, two wells 700 and 250 feet deep. Hardness of 130 parts per million. Water is probably from the Vicksburg limestone region. At Live Oak we have our first treated municipal supply. Chlorine is used to sterilize the water from a 660-foot well. The water is influenced by drainage wells nearby. The water at Live Oak has a hardness of 195 parts per million. Lake City, the first stop in Florida for hundreds of thousands of tourists from the midwest last fall, has a municipaly owned deep well supply, taking water from a 400-foot well. The water is hard, 200 parts per

million. The presence of sulphur is in the form of H_2S. On to Jacksonville the metropolis of the State. The nearer the coast we get the deeper are the wells, the water harder and more sulphurous. Jacksonville, with a municipal supply of wells ranging from 750 to 1200 feet deep, free flowing wells and water highly laden with H_2S. The water is allowed to spill over into large covered reservoirs. The aeration removing a large portion of the dissolved gas. The water is also chlorinated. The Jacksonville city water has a temperature of about 82°F. It has a hardness of about 300 parts per million. Many small residential areas are served about Jacksonville by simply drilling a well and running mains from it, using natural pressure. On account of the hardness of the Jacksonville water and the decreasing flows from the wells, two studies have been made of surface supplies nearby, the Black Creek project and the St. Mary's River project. Both have as their objective a soft water supply. Color removal will be a problem in either. The matter involving from eleven to three million dollars has not been voted upon by the people.

St. Augustine after having used for years a free flow of sulphur water having a hardness of from 544 to 714 parts per million and a chloride content of 154 to 635 parts per million has developed where it "couldn't be done," a supply of shallow well water on the mainland. This water has a hardness of 250 parts per million and a chloride content of 50. It is aerated and chlorinated.

In all this area, 360 miles across and over 50 miles deep, not a single surface supply. With rolling sandy clay land and many streams adaptable for surface supplies not a one is used. Small towns, rural population, deep well supplies—nearly 100 per cent municipally owned and operated. In this area are two old time watering resorts. Hampton Springs in Taylor County and White Springs in Hamilton County. Both are cold sulphurous waters. White Springs boils up through a large circular hole in the rock and is located on the shore of the Swannee River and forms a stream of moderate size. Its flow is estimated at 32,400 gallons per minute. The flow probably comes from the Vicksburg limestones. At Panacea in Waukulla County a very large spring of soft water is used for medicinal purposes. At Green Cove Springs in Clay County, the Qui-si-sana springs merge from a circular orifice several feet deep in the bank of the St. Johns River—the water is usually 78°F. and sulphurous. At Suwannee in Suwannee County there is a sulphur

spring discharging 52,000 gallons per minute of hard sulphur water, while near Falmouth a similar spring yields over 100,000 gallons per minute.

Now let us go down the Gold Coast, the East Coast of Florida to Miami!—the Magic City. Leaving St. Augustine we pass Hastings, potato center, having flowing wells for a supply, privately owned and operated. These wells are 250 feet deep, having a hardness of 800 parts per million and total solids of 1400 parts per million with 200 parts chlorides. Natural pressure is used by the Hastings Water Company. Ormond has just put into service a new supply from four 200-foot wells, all free flowing. The water is softened by addition of lime. Daytona Beach now includes the three cities of Daytona, Daytona Beach and Seabreeze. Daytona has 8 wells from 162 to 250 feet deep. The water is aerated to remove sulphur and treated with lime to reduce hardness. The treatment is simply to aerate, add lime, allow to settle, decant and pump to town. The entire new system and plant to serve the greater city is now being designed by Metcalf and Eddy of Boston. New Smyrna is just completing a new pipe line for the city wells 3 miles west and has just drilled two more. The present supply is from two 180-foot wells with a hardness of 840 parts per million, a chloride content of 1500 and a total solids of 2940 parts per million. Going south Titusville is the next stop. Here four 20-foot wells are used. They are located to the west of the city to avoid salt water infiltration. Even here a hardness of 230 parts per million is reported. Cocoa, after using both deep and shallow wells, is now, on account of hardness and salt water, contemplating going 5 miles west to the headwaters of the St. Johns River for a surface supply.

Ft. Pierce uses 800-foot wells yielding free flow. The water is quite hard, 332 parts per million, and sulphurous. It is slightly aerated. A new three million gallon rapid sand filtration, iron removal plant is being built to use a savanna water some 2 miles south of the city. Color and iron will be problems as well as quantity of water. All the foregoing plants have been municipally owned and operated, and tendency toward shallow wells to avoid excessive hardness, salinity and sulphur is noted. The future drift is toward softer waters.

Stuart is our first privately owned and operated water system of any magnitude on the east coast. Here 60-foot wells are used and no treatment provided. West Palm Beach is served by the West

Palm Beach Water Company, a Florida East Coast Company property. Water is taken from a series of lakes or savannas, just west of the city and the sand dunes that run along the entire coast. This highly colored water is treated with alum, aerated, settled, filtered and chlorinated. The color is reduced from 102 to 23 parts per million. Mr. Y. C. Mar, chemist in charge, states that although they deliver a water to the mains having a pH of 6.8 no red water troubles result. Shallow wells, about 90 feet deep, are also pumped to help on peak loads. The present plant of six million gallons capacity is being enlarged to twenty million gallons under the direction of Mr. Pirnie of Hazen and Whipple of New York. With this added capacity, the wells will probably be abandoned. An interesting feature of this plant is that the filters and galleries are not housed at all. The clear well is covered.

From West Palm Beach one travels through the "Promised Land." Subdivisions are on each side. Boca Raton is an incorporated city of some 64 square miles including three large subdivisions, Croissantania, Mitzner's, Boca Ratone and Del Ratone, in addition to the former town of Boca Ratone. Population now is about 500. Water is taken from four 40-foot wells and the Kewannee pressure tank system is used. As each subdivision grows it is proposed to locate a small water system in each and formally connect them. There are 50 taps to this supply.

Ft. Lauderdale, the next city, has just spent $120,000 on a new 1,600,000 gallon plant. Two 16-inch shallow wells supply the city. Old wells, although only 80-foot deep, are to be abandoned because of salt water infiltration. Hollywood, Mr. Young's development, has been incorporated and now includes the old village of Dania which had a municipally owned supply from shallow wells, about 70 feet deep. The old wells yielded a water of about 322 parts per million hardness. Hollywood uses an old Kewannee horizontal pressure tank system at one plant and direct suction on six 65-foot wells at another plant pumping direct to the mains. A complete central water softening plant is hoped for in the near future.

The Magic City is next, Miami, the Mecca of Florida-bound tourists. Miami is supplied largely from shallow wells in what is known as the Hialeah section some 7 miles west of the city. The water is hard, having about 250 parts per million permanent hardness, with a color of about 60 parts per million. The plant is a lime softening filtration plant. It was designed for 10 million gallons per day in

1924 and completed in May 1925. Four months later in September it was decided to double the capacity and this has just been done. Even now, however, certain sections of the city are served by untreated shallow well water from scattered stations. The city of Miami owns and operates the Hialeah softening plant, selling the output to the Miami Water Company who retail it about Miami and also sell the municipality of Miami Beach, who in turn retail it. The softening plant is of the most modern design, being designed by Alvord, Burdick and Howson of Chicago, with Chas. P. Hoover as consultant chemist. Dorr clarifiers and equipment are used. The water is carbonated and then filtered. Spanish architecture is well utilized in creating a very pleasant looking filtration plant. It is hoped that the drainage in the Everglades will not cause the salt water to come that far inland and spoil the wells.

Coral Gables adjoins Miami and here the supply is from shallow wells about 80 feet deep, each well has its own pump and chlorinator. It is privately owned and operated, having just been sold by the developers to the Florida Power and Light Company. Homestead is our last stop on the Florida East Coast Mainland. Here is a municipality owning and operating a softening plant. The well is 72-foot deep and the water is aerated, treated occasionally with lime and soda ash, settled and filtered. Water with about 190 parts per million hardness is treated. Owing to the fact that the operator judges results by the clearness of the water, the softening process has been discontinued. The plant has been in service about a year and the water chemically treated about five times. Homestead is the site of one of the Florida East Coast Railway line softening plants and the water here is loaded into tank cars and hauled to the terminus at Key West. None of the keys have fresh water available except cistern rain water. Wells have always encountered salt water. So the water is hauled a distance of 122 miles in iron tank cars. The demand for a water supply at Key West was such that last year Governor Martin called a special session of the state legislature last fall to pass a bill authorizing the creation of the Key West Water District. The Commissioners of the District have now practically settled on a plan to bring water from near Homestead in a 122-mile pipe line along the Florida East Coast railway right-of-way and trestles or along the new overseas highway now being constructed to connect Key West to the Mainland. No pure water in Key West has been the check-rein on the city's growth. It is understood a

private company is to put down the pipe line under guaranteed yearly sales to the city, Florida East Coast Railway, etc. In all this strip of land nearly 500 miles from St. Augustine to Key West, possibly averaging 5 miles in width, we have sand dune, waste land and sand country to coral rock formation, with the arms of the Atlantic on one side and the St. Johns and Everglades on the other. Not a spring of any size is found and the deep well waters in the Vicksburg strata are hard and often very saline. Most supplies are shallow wells set far back from the river front. It is very possible that these in time will become salt and the eyes of the future rest upon Lake Okeechobee and the Everglades drainage canals as the future water supply of the southern east coast.

Now we will go by boat to the winter home of Ford and Edison, Ft. Myers. Here is a municipal supply from deep wells sunk into the Vicksburg formation, a hard sulphurous supply, 650 parts per million, with over 700 parts per million chloride, has led the city to plan the use of the headwaters of the Caloosahatchee River. The lower west coast cities are situated on salt water which extends far inland since the country is very flat. Punta Gorda on Charlotte Harbor has just brought in a relatively soft water supply from a group of 95-foot wells. The supply is municipally owned and operated. Sarasota, the Wonder City, has a municipal supply, deep wells, about 400 feet deep sunk into the Vicksburg formation yielding a hard 556 parts per million water. Bradenton uses shallow wells only 85 feet deep and has been long experimenting to find an increased supply of soft water. The present supply has a hardness of nearly 1100 parts per million, a chlorides content of 240 parts per million and quite sulphurous. The yield is barely sufficient to supply the city. Here is an ideal location for a District Water Supply, taken from the headwaters of the Manatee River, with a color removal and softening plant to serve Bradenton, Palmetto, Manatee, Ellenton and possibly Sarasota.

Tampa, the west coast metropolis, has just put into service a new water softening color removal, filter plant, in the Hillsborough River in the northern section of the city. This plant, designed by Nicholas S. Hill, Jr. of New York, contains many splendid features and worthy of a special paper before this body. Suffice to say everything possible is metered, everything possible to secure flexibility of operation has been installed and the latest features in filtration design have been incorporated. The raw water varies from a fairly

soft colored water, due to swamps and vegetation on the water shed during high river stage, to hard water of low color during low water stage in the river, due to the numerous springs discharging from the limerock into the river. In addition to lime and alum treatment the plant is using sulphur dioxide as a bleaching agent for removal of color. This is done by burning sulphur, passing the sulphur dioxide over a water scrubber and adding the H_2SO_3 thus formed to the water. Carbonization and chlorination are also used. The city owns the plant and has provided a complete chemical and bacteriological laboratory and trained operating personnel. The plant has a capacity of fifteen million gallons per day. The deep wells which long supplied Tampa will be held in reserve. Continued heavy draft during the fall of 1925 had rendered the salt content very noticeable. These wells are also in the Vicksburg strata about 200 feet deep. The presence of drainage wells used to dry surface ponds and depressions tends to pollute the underground water. Operating inside the city limits are two good sized water companies, the Seminole Heights Water Company and the Purity Springs Water Company. Just below the city water filtration plant is the famous Sulphur Springs. This flow comes from a large hole in what is termed the Tampa formation limestones and flows about 65,000 gallons per minute. It is used as a swimming pool.

Crossing the longest highway bridge in the World, Gandy Bridge, across Old Tampa Bay we are in the Sunshine City, St. Petersburg. The municipal supply here is from 200-foot wells drilled about the shores of two small lakes within the city limits. The water is aerated and chlorinated. It will average about 400 parts per million hardness. The wells are of the Layne Bowler type. The city has now engaged Mr. Hill to report on a new water supply. Other cities on the Pinellas peninsular such as Safety Harbor, Clearwater, Dunedin, Passagrille, etc., have deep well supplies with no treatment. Most of the supplies are muncipally owned and operated. At Safety Harbor is a well known spring having medicinal qualities, Espiritu Santo Spring—a spring having about 1800 parts per million chlorides and 900 hardness, 110 parts per million magnesium and 1000 parts per million sodium and potassium. The yields vary slightly, but the salt and sulphur water is used for bottling and medicinal purposes. Tarpon Springs, the world's largest sponge market, is now building a filter plant to use Lake Butler Water.

We will now go inland coming north from Okeechobee Lake.

Okeechobee City has just completed a new filtration plant of the rapid sand type and will be the first real test plant on Lake Okeechobee water. Lime and alum and chlorine will be used. Color removal will be a problem and at times vegetable growths. Moore Haven and Clewiston also have small filter plants using lake or canal water. Coming northwest we enter the famous ridge country, the land of lakes by the thousand and orange groves by the mile. Small towns are frequent, all using deep well supplies. The waters usually have a hardness of between 100 and 200 parts per million. Sulphur is not a problem. Bacterially the water is excellent. Although a town may have as high as 100 lakes within the city limits, water is taken from deep wells. A little to the west in the Peace River Valley, free flows are obtained, but the water is hard and sulphurous. Most all of the supplies are municipally owned and operated. About Orlando we have all deep wells, drilled into the Vicksburg strata and producing hard water. We have also many drainage wells sunk for farm drainage and storm water drainage, but fortunately no contamination of a public water supply has been ever recorded due to drainage wells in this vicinity. Orlando takes her water from Lake Ivanhoe, using rapid sand filters and chlorine for purification. This plant has been described in THE JOURNAL (March, 1926). It is the only filter plant in this section and is under chemical and bacteriological control. A small group of privately owned deep well plants are centered about Eustis. Mount Dora is putting in a new lake supply with chlorine to augment a deep well hard water.

Ocala, in the Kingdom of the Sun, uses deep well water, chlorinated. Six miles east is the famous Silver Springs, the largest spring in the world, creating a navigable river at its source. The water issues from several openings and the flow is about 385,000 gallons per minute. The water is crystal clear, objects in 80 feet of water being clearly visible at the bottom, fish, turtles and aquatic life can be observed clearly through glass bottomed boats touring the springs. This spring issues from the porous and cavernous Vicksburg limestones and as it does not travel very far through it, the water is not very hard. Another spring nearby is Blue Springs near Juliette with a flow of about 350,000 gallons per minute. Gainesville, University City, uses deep wells, 380 feet into the Vicksburg strata and also a spring supply which is chlorinated. The land about Gainesville and Ocala is rolling country full of limestone sinks. Small ponds and depressions

abound. One large sink near Gainesville called Paynes Prairie, was at one time the outlet of a large stream. The outlet became closed by logs and rubbish and a great lake was formed. The sink

TABLE 1

Florida public water supplies

MUNICIPALLY OWNED AND OPERATED	PRIVATELY OWNED AND OPERATED
Surface supplies—untreated	*Surface supplies*—untreated Bellview
Surface supplies—chlorinated Mount Dora (Part)	
Surface supplies—filtered and chlorinated Tarpon Springs Moore Haven Okeechobee Orlando Tampa (Part)	*Surface supplies*—filtered and chlorinated Clewiston West Palm Beach (Part)
Shallow wells—no treatment Titusville Cocoa Melbourne Lake Worth Boynton Delray Boca Raton Dania Hollywood Bradenton	*Shallow wells*—no treatment Stuart Elfers Perry Miami (Part)
Shallow wells—softened Fort Lauderdale Homestead	*Shallow wells*—softened Sunny Isles
Shallow wells—chlorinated St. Augustine (Part)	*Shallow wells*—chlorinated Coral Gables West Palm Beach (Part)
Springs Tampa (Part)—chlorinated Palatka (Part)—chlorinated Gainesville (Part)	
PRIVATE SOURCE—MUNICIPAL DISTRIBUTION	**MUNICIPAL SOURCE—PRIVATE DISTRIBUTION**
Deep wells—no treatment Dunedin Haines City Winter Park	
Shallow wells—no treatment Delray Beach	*Shallow wells*—no treatment
Shallow wells—softened Miami Beach	*Shallow wells*—softened Miami (Part)

TABLE 2

Florida public water supplies

MUNICIPALLY OWNED AND OPERATED		PRIVATELY OWNED AND OPERATED
Deep wells—no treatment		*Deep wells*—no treatment
Bunnell	Newberry	Orange City
New Smyrna	Alachua	Safety Harbor
DeLand	Archer	Avon Park
Lake Helen	Starke	Brewster
Punta Gorda	Lake City	Pierce
Plant City	Pensacola	Winter Haven
Largo	Milton	Lake Wales
Clearwater	Bonifay	Tavares
Zephyrhills	Chipley	Eustis
Dade City	Green Cove Springs	Fruitland Park
Passa-Grille	DeFuniak Springs	Apopka
Brooksville	Marianna	Wiersdale
Inverness	Panama City	Bagdad
Crystal River	Apalachicola	River Junction
Dunnellon	Blountstown	Alton
Bowling Green	Quincy	Tampa (Part)
Sebring	Havana	Bellair
New Port Richey	Tallahassee	
Mulberry	Monticello	
Lakeland	Greenville	
Fort Meade	Madison	
Bartow	Jasper	
Auburndale	Jennings	
Lake Alfred	Mayo	
Davenport	Eagle Lake	
St. Cloud	Sarasota	
Bushnell	Daytona (Part)	
Center Hill	Tampa (Part)	
Webster	Mount Dora (Part)	
Umatilla	Gainesville (Part)	
Leesburg	Palatka (Part)	
Groveland		
Clermont		
Winter Garden		
Ocoee		
Longwood		
Williston		
Deep wells—softened		
Ormond		
Daytona (Part)		

TABLE 2—*Continued*

MUNICIPALLY OWNED AND OPERATED		PRIVATELY OWNED AND OPERATED
Deep wells—chlorinated		
St. Petersburg		
Sanford		
Ocala		
High Springs		
Live Oak		
Flowing wells—Artesian, no treatment		*Flowing wells*—Artesian, no treatment
Fernandina	Arcadia	Hastings
Jacksonville Beach	Wauchula	Century
Callahan	Frostproof	Everglades
Port Pierce	Kissimmee	
Fort Myers	Crescent City	
Palmetto	Graceville	
Manatee		
Flowing wells—chlorinated		
Jacksonville		
South Jacksonville		
Flowing wells—softened		
Vero Beach		

later reopened and the basin drained effectively putting an end to the steamboat traffic on the lake. Only a few caverns are known and they are not developed here as in the Shenandoah Valley in Virginia.

Palatka, on the St. Johns River, has a municipally owned and operated supply of free flowing wells, 250 feet deep and a spring. Palatka is interesting in that the supply from the springs is piped separately about town from the well supply, thus there are two systems, a soft and a hard water system.

Some interesting facts about the Florida water supplies can be gathered by a study of the United States Geological Survey chemical analyses of our waters and a study of Water Supply Paper No. 319 of that Service, although many new supplies have been developed since then. At present we have 160 water supplies in Florida serving the general public. We have not listed the small supply from free flowing wells piped to 20 or 30 houses unless it is the only supply in the vicinity. Thus in Jacksonville we omit supplies of Brentwood, Ortega, St. Johns Park, Panama Park, etc. in the suburbs about the city. Large subdivisions are noted only when the supply is in actual use. To keep up with the water supplies of subdivisions is well nigh impossible and we

always urge prospective buyers to investigate before you invest, see where your supply is coming from. It is interesting to note that from August 1, 1925, to January 1, 1926, in spite of an embargo on many commodities, three cast iron pipe manufacturing companies

TABLE 3

Florida public water supplies

MUNICIPALLY OWNED AND OPERATED			PRIVATELY OWNED AND OPERATED		
A. Deep wells	91		A. Deep wells	19	
1. Static	74		1. Static	16	
a. no treatment		67	a. no treatment		16
b. chlorinated		5	b. chlorinated		0
c. softened		2			
2. Flowing	17		2. Flowing	3	
a. no treatment		15	a. no treatment		3
b. chlorinated		2	b. chlorinated		0
B. Shallow wells	13		B. Shallow wells	7	
1. no treatment	10		1. no treatment		4
2. chlorinated		1	2. chlorinated		2
3. softened		2	3. softened		1
C. Surface supplies	6		C. Surface supplies	3	
1. no treatment		0	1. filtered & cl.		2
2. filtered & cl.		5	2. chlorinated only		0
3. chlorinated only		1	3. no treatment		1
D. Springs	3		D. Springs	0	
1. no treatment		0			
2. chlorinated		3			
		113			29
		5			3
		108			26

5. Private source, municipal distribution
1. Municipal source, private distribution
14. Subdivision supplies
7. Institutional supplies

Grand total 160 supplies

126. Deep well supplies
26. Shallow well supplies
4. Spring supplies
10. Surface supplies (7 filtered and chlorinated)
8. Filtered supplies
19. Chlorinated supplies
7. Softening plants

reported the sale of over 660 miles of pipe for water supply purposes from 2-inch up.

From tables 1, 2 and 3 you will note we have 109 municipally owned and operated water plants in Florida and 26 privately owned and operated. We have 5 supplies with private source and municipal distribution systems and one large supply with municipal owned source and private distribution systems. Of the 141 cities thus listed deep wells are used exclusively in 107 cases, and 6 partly served. Shallow wells are used in 20 places, or 2 in part. Surface supplies are used in 6 cases and 3 in part.

The State Board of Health maintains a laboratory at Jacksonville attached to the Engineering Division for the purpose of bacterial examination of the waters. No charge is rendered, but cities are required to own their own shipping cases which we order for the special price of $14.50. Tests are made as frequently as the cities desire. Where cities do not own their own sample case, our field inspectors, 11 in number, and two field engineers collect samples in State Board of Health boxes. Samples are shipped iced and usually received at Jacksonville within 24 hours by special handling procedure with the express companies. It is expected to have chemical control over the plants starting next year. The United States Geological Survey has just this year finished chemical tests on over 500 waters in Florida.

In conclusion, let me give you the sage advice as published in our leading newspaper under a dispatch line from Sebring, Florida:

> Before locating in Florida or any other state in the Union, the first thing that should be considered is the water as all physicians and surgeons will tell you that your health and the health of your family depends upon the quality of water which you drink. No matter how beautiful your home or surroundings or how delightful the weather or how much money you can make, if the water is not of the best, all the other things count for nothing. Good health and no one will deny it is the most consideration to man on earth.
>
> Sebring's water is rightly called water from the fountain of youth. It is not only medicinally good for all ailments, but it clears the complexion, makes our women more beautiful, our men more manly—vanity cases, setting up exercises are not needed in Sebring. The water even makes you immune from typhoid fever. It seems but wilful waste for the inhabitants of Sebring to bathe and wash their clothes, sprinkle their lawns and freshen their flowers, with water that is equal if not superior to the highly retailed health water.

THE PROBABLE FUTURE DEVELOPMENT OF RAILWAY WATER TREATMENT[1]

By C. R. Knowles[2]

The railroads have passed through the period of pioneer development in the treatment of locomotive water supplies and are now approaching an era of refinement that will undoubtedly lead to still greater development. The foundation of water softening and treating practice has been laid, and it is unlikely that there will be any radical departure from these principles. At the same time it is becoming more and more apparent that refinement must take place in many of the present methods of treatment and that careful consideration should be given to the possibilities of new methods.

As far as the railroads are concerned, water treatment has not only been an economic necessity, but in many cases it has been an actual operating necessity. As train loads became heavier and boiler pressures and ratings were increased the treatment of many of the worst waters became imperative. The available information regarding methods of treatment was limited, and many of those who first undertook to treat the water were confronted with the problem for the first time and were probably in the same state of mind as the first man who started out to soften water more than eighty years ago, the idea in the beginning being simply to get the water in a tank, add the necessary chemicals and let it settle. Certain refinements were developed through experience as time went on and it may be expected that the art will continue to develop by the same process.

It was quite natural that the worst waters should receive attention first, for while the less troublesome waters of comparatively low scaling content were costly from the standpoint of fuel economy and boiler maintenance, they did not interfere seriously with train operation. As treatment has been extended to include practically all of these very bad waters, the water that was considered fair a few years

[1] Presented before the sessions of Committee No. 19, Boiler Feed Water Studies, Buffalo Convention, June 9, 1926.

[2] Superintendent Water Service, Illinois Central System, Chicago, Ill.

ago has become the bad water of today. The value of water treatment has become so well established through records of savings in boiler repairs, fuel economies and the reduction of engine failures that it is becoming apparent that treatment must be extended to include these waters of so-called fair quality. The cost of providing adequate motive power for the movement of trains is constantly increasing, and with investments of from $60,000 to $70,000 each for locomotives, poor water conditions can no longer be tolerated.

Longer engine runs are another factor in locomotive operation that is making better water conditions necessary. The Northern Pacific recently made a record breaking continuous freight run in which a Mikado type coal-burning locomotive pulled a train from Seattle, Wash., to St. Paul, Minn., without being uncoupled from the train and without receiving any terminal attention enroute. The distance of 1,898 miles over three mountain ranges with maximum grades of 2.2 per cent was covered in 109½ hours total time. The Great Northern a short time ago ran an engine and train from Seattle to St. Paul and return, a total distance of 3462 miles, while the Burlington handled a train of 90 cars loaded with 6450 tons of coal from West Frankfort to Chicago, a distance of 413 miles with one mountain type locomotive. The Southern Pacific is running passenger trains regularly betweed El Paso and Houston, Texas, a distance of 832 miles, without changing engines. While many of these long runs are test runs today, they will be a regular thing in the near future.

All of these developments in locomotive operation call for water supplies of the highest quality, and it is evident that the railroads are going to demand much more of the water service engineer in the future than they have in the past. Some of the improvements in the quality of water will no doubt be accomplished through the development of new and better supplies, but in the great majority of cases it will mean the improvement of existing facilities by establishing additional treating plants, etc.

REMOVAL OF SUSPENDED MATTER

One of the problems that will undoubtedly receive more attention in the future than it has in the past is the removal of mud or other suspended matter from railroad water supplies. While mud removal has not been altogether neglected, it has hardly received the attention it deserves, to say the least. This apparent neglect is not due entirely

to failure to appreciate the importance of removing suspended matter, but rather to the fact that through necessity efforts were concentrated on improving waters high in dissolved solids, and in some instances to lack of sufficient finances to provide the required facilities.

The rivers of the Middle West carry an average of from 1 to 1½ pounds of suspended matter per thousand gallons of water throughout the year with a maximum of 5 or 6 pounds during the freshet seasons, while the Southern and some of the Western streams carry still more. The objection to the presence of mud or other suspended matter in boiler waters is not altogether due to the necessity for frequent washing of boilers to prevent foaming and possible mud burning of sheets due to the use of turbid water, but also to the fact that the mud is deposited on the tubes and sheets and in the presence of dissolved solids helps to form scale.

Mud removal installations consist largely of sedimentation basins alone. They are fairly effective where the mud is heavy and settles rapidly, but the most satisfactory results can be secured by coagulation and sedimentation, followed by filtration. Most turbid waters carry considerable amounts of scale forming solids in addition to the suspended matter and as softening the water as well as removing the mud add little to the cost, the development along this line will probably include complete softening equipment for the removal of matter in solution as well as in suspension.

FILTERS

Another possible future development of water treatment is the more extensive use of filters. A large majority of the railway water treating plants depend entirely upon sedimentation to produce a clear treated water, although the limitation of sedimentation alone in clarifying the water is recognized in the extensive use of iron and alum in various forms as an aid to the precipitation of the sludge.

It is a commonly accepted fact that the temporary hardness remaining in water after being softened with lime and soda ash is materially lowered by filtration through sand. Where filters are used in conjunction with lime and soda ash softeners no other coagulant is required, as a general rule. The amount of suspended solids that may be removed by filtration, even after treatment and sedimentation, is of appreciable value, not only in reducing the

hardness and preventing after-precipitation in distribution systems, but also in reducing the losses in fuel and water through less frequent blowdowns of boilers. Filtration may well be compared to a continuous blowdown in its effect, as the suspended matter that would otherwise remain in the water after ordinary treatment is being removed constantly as the water is passing through the filter.

The additional cost of filters has been fully justified by the roads that are using them and their universal adoption as an adjunct to water softening will undoubtedly follow as their value becomes better recognized.

TREATING TANKS

Improvement in design of water treating plants will no doubt include a more efficient type of treating tank, particularly in regard to sludge removal. Many different designs have been followed in the construction of reaction and sedimentation tanks, the most widely used being the common flat bottom tank, either of the standpipe type with the bottom at the ground level, or erected on an elevated tower. In this type of tank, as commonly used, the sludge is deposited over the entire bottom of the tank, its removal necessitating the construction of an expensive sludge-collecting system, which at its best leaves much to be desired. This sludge removal system usually consists of an arrangement of pipes with openings placed at uniform intervals over the bottom of the tank. In the large tanks they are so arranged that they may be operated in sections with from two to four sludge valves for each tank. Another type is so arranged that the collecting pipes may be rotated over the bottom of the tank. None of these systems are entirely satisfactory for they do not completely remove the sludge and they are extremely wasteful of water, as the sludge nearest the outlet is the first to be picked up and two-thirds of the openings are usually discharging clear water before the sludge at the outer edge of the tank is disturbed.

One of the principal developments in the design of treating tanks is the conical bottom tank with a large riser pipe. The angle or slope of the cone is 45 degrees, and the drum or riser pipe is from 4 to 6 feet in diameter and serves as a sludge-collecting chamber. The sludge falls to the bottom and is collected in the mud drum as it forms, where it is easily and completely removed through a single opening and with a minimum waste of water. Actual tests to determine the amount of water used in removing sludge show that the flat bottom tank requires

from five to ten times more water in sludging than a conical bottom tank of proper design.

The remarkable efficiency of the conical bottom tank in sludge removal and economy in the use of wash water are factors that will result in its more extensive use for water treatment. Experiments are also being conducted with continuous sludge removal systems and tanks of other designs, and it is evident that the development of water softening will include tanks of more efficient design.

ZEOLITE SOFTENERS

Zeolite water softeners are receiving considerable attention as a possible method of treating water for locomotives. One installation on a Western road is being watched with much interest and the results obtained will undoubtedly be a factor in determining their use by other roads, as well as extending their use on the road in question.

The chief concern regarding the use of Zeolite is on account of the possibility of increased foaming due to the conversion of the various elements in the untreated water to sodium compounds in the treated water, which is characteristic of Zeolite treatment. It is claimed that the foaming may be minimized with the exclusive use of Zeolite treated water, which is practically free from suspended matter. This is not always possible on a railroad unless entire engine districts are equipped with Zeolite treatment. Another factor which has reacted against their use for railroad supplies is the fact that with certain waters pre-treatment is necessary. For example, if the water contains an appreciable quantity of iron it must be pre-treated before passing through the Zeolite softener, or if the water is turbid it must be filtered before it can be handled successfully. With the lime and soda ash plant no pre-filtration are required, as sand filtration after reaction and sedimentation is provided in all modern equipment.

A possible solution of the problem is a combination lime-soda-Zeolite plant with pre-treatment by lime and soda ash for the removal of the bicarbonates of lime and magnesia, iron and free carbon dioxide, the neutralization of sulphates and the reduction of organic matter, silica and alumina, followed by the Zeolite treatment to produce a water of zero hardness with a minimum of suspended matter. If this type of plant can be developed successfully and economically it is not at all unlikely that Zeolite treatment will be further extended in the treatment of locomotive supplies.

INTERNAL TREATMENT

Internal treatment of boiler waters involves the introduction of chemicals and other substances into storage tanks, the tenders of locomotives or direct into the boiler. This method of treatment as applied direct to boilers is the oldest form of treatment known, probably being as old as boilers themselves. It has been improved upon from the old hit-and-miss form of treatment until it has become a generally accepted process. Reputable manufacturers offer forms of treatment that are based upon chemical examination of the water and that are producing good results. The combination of chemicals used in this form of treatment is generally referred to as boiler compound. The future development of this form of treatment will be the elimination of the quack cure-all compounds and more uniform methods of feeding the chemicals to the water, probably through a more extensive use of compound feeders.

GENERAL

Stationary power plants are adapted to the use of many devices for the purification of boiler feed waters that cannot be used on locomotives on account of the limited space available. Therefore, it is impossible to make any prediction as to the probable future use of de-aerators, de-concentrators, etc., on locomotives, although their development for this purpose is not beyond the realm of possibility. In fact many of the feed-water heaters used on locomotives embody the feature of oxygen removal in addition to heating the feed water. Some authorities claim great benefits from this feature in preventing corrosion, and it is possible that as more locomotives are equipped with the open type of feed water heater they will become an important factor in improving the quality of the feed water. The claim is also made that thermic syphons and plates as installed in locomotive boilers tend to improve feed water conditions, particularly as regards corrosion, through increased circulation of the water in the boiler.

It is impossible to make any prediction as to the possible future development in the use of the less common reagents in water softening, such as the barium salts for example. As with many other reagents, treatment with barium is not yet commercially practicable as a rule, although barium salts may ultimately be manufactured at a cost that will result in their more general use. However, the principal

developments, in the near future at any rate, will be based upon the lime-soda ash treatment.

There is ample room for further development in railway water treatment; at the same time there are certain limitations that must be considered. Water softening and treatment for steam making must of necessity be kept within the bounds of the more simple reaction and commercial reagents.

STREAM POLLUTION AND ITS EFFECTS[1]

By N. T. Veatch, Jr.[2]

We are all fairly familiar with the results of stream pollution as evidenced by the black, ill smelling water of some familiar stream, but there seems to be a general lack of understanding on the part of the public at large, in regard to the importance of this question and its relation to public welfare. The popular conception of "stream pollution" seems to be synonymous with "nuisance" as regards offense to smell and sight, whereas this feature is but one of the phases of the subject and by no means the most important.

The protection of our streams, and other bodies of water as well, is nothing more nor less than the protection of a national resource, in fact, one of our most valuable national resources, since it concerns the all important question of public water supply and, therefore, all city dwellers in locations where ground water supplies are not available. Some industries, as fisheries, are entirely dependent on reasonably pure stream water and all industries are dependent on water supplies of some nature.

By no means the least important feature of this question is the fact that it is becoming more and more acute each year through the increase in urban population, the increase in the number of municipal sewer systems, the increase in industries which produce objectionable trade wastes and in the rapidly increasing number of cities which are being forced to use surface water to get an adequate supply.

The increase in the urban population of the United States is shown in the following table adapted from the United States Census which shows that the urban population of the United States in 1920 exceeded the rural by approximately 3 million, and there is every indication that this excess will continue to increase.

[1] Presented before the Iowa Section meeting, November 4, 1926.

[2] Consulting Engineer, Kansas, City Mo.

	1900	1910	1920
Population of United States.....	76,000,000	92,000,000	106,000,000
Rural.....	46,000,000	50,000,000	51,500,000
Urban.....	30,000,000	42,000,000	54,500,000

There seem to be no available authentic data on the number of sewer systems in the United States, but, based on experience in the central west, it may be stated that at the present time a town of 2000 without a municipal sewer system is decidedly exceptional, and that probably 75 per cent of these systems have been built in the past 20 years. It is, therefore, reasonable to assume that within 20 years, practically all towns of 1000 and over will be served with sewers. Similarly, there seem to be no available authentic data in regard to the change of municipal ground water supplies over the country to surface water, but again judging from experience in the central west where numerous cities have had to make this change, through inadequacy of ground water supplies, this factor is important.

The Manual of the American Waterworks Association estimates the number of water works in the United States as 9850 in 1924, of which 36 per cent are surface supplies. In view of the fact that practically all of the cities in excess of 30,000 are included in the 36 per cent, it is probably safe to say that 75 per cent of the urban population of the United States, is served with surface water from streams, lakes or artificial reservoirs, and that approximately half of this number or 20 million persons, are served from water supplies taken from streams which are subject to pollution from municipal sewage, trade waste, or drainage from barn yards or feed lots. When it is considered that the above condition exists at such important centers as Philadelphia, Pittsburgh, Baltimore, St. Louis, Cincinnati, Louisville, New Orleans, Kansas City, Omaha, Oklahoma City and many others, the importance of this question may be seen.

The present standard of purity as set forth by the International Joint Commission in 1913, in an extensive investigation of boundary waters, considered as safe for surface waters which are to be purified by modern plants, consisting of settling and coagulating basins, filters and sterilizing equipment, demands that "the raw water shall not have objectionable odor, color, or taste, and shall not contain more than 500 bacteria of the intestinal type (B. coli) per cubic

centimeter." Practice has shown that the above is not a bad standard, although satisfactory water is produced at many places where this standard is often exceeded, but the fact remains that the use of such water is dangerous and puts too heavy a load on the purification plant. This extra burden surely should fall on those agencies causing the pollution, which calls for purification of sewage and trade wastes where pollutions exceed a safe limit. As a matter of fact some of the streams of the country are called upon to furnish water for municipal water supplies at a rate which in the aggregate exceeds the flow of the stream at times. This was true of the Verdegris River in Kansas in the fall of 1917, when the aggregate amount of water used by Kansas municipalities, along its course, was approximately three times its flow at the Oklahoma State line.

The chief source of stream pollution is undoubtedly municipal sanitary sewage which may be made up of anything, but which is reasonably uniform except as to trade wastes.

For the study of stream pollution the character of sewage is customarily reported as solids both in suspension and in solution, as organic matter in the form of total nitrogen and "oxygen consumed" and as "biochemical" or "biological oxygen demand" which last is a measure of the oxygen required to mineralize the organic matter in the sewage.

Bulletin 143 of the United States Public Health Service states that average domestic combined sewage without major trade waste will contain the following constituents in grams per capita per day.

Total Solids	439
Dissolved Solids	330
Suspended Solids	109
Total nitrogen	11.4
Oxygen consumed	51.5
Biological oxygen demand	100

For a city of 10,000 persons, therefore 1,000,000 grams or 2204 pounds of oxygen will be required for sanitary sewage.

Trade wastes are of course more variable and require special study in each instance. They may range from sawdust which has practically no effect on the water, to wastes from coal tar product works which cause objectionable tastes in waters in several million dilutions of pure water.

Several specific wastes have been studied and found to contain total nitrogen and oxygen consumed as shown in table 1, which also gives the approximate equivalent of the waste in terms of sanitary sewage.

TABLE 1

*Estimated average amounts of total nitrogen and oxygen consumed contained in various industrial wastes, per unit of product, raw material or labor, with approximate equivalents in domestic sewage**

NATURE OF WASTE	UNIT OF MEASUREMENT	GRAMS PER UNIT		APPROXIMATE NUMBER OF PERSONS REQUIRED TO PRODUCE THE EQUIVALENT OF THIS WASTE IN DOMESTIC SEWAGE
		Total Nitrogen	Oxygen Consumed	
Slaughter house...	1 animal	238.6	183.7	7
Pork packing.....	1 animal	243.1	307.5	9
General packing...	1 animal	171.5	344.2	8
Glue making.....	1 employee	3,193.3	4,427.1	102
Soap making.....	1 employee	27.2	2,084.7	33
Wool scouring.....	100 lb. raw material	340.2	1,551.3	30
Wool cloth dye and scour.....	100 lb. raw material	704.4	7,112.4	124
Cotton cloth, bleach and dye..	100 lb. raw material	1,111.3	6,159.9	115
Paper—sulphate pulp.....	1 ton pulp product	1,315.4	647,741.0	13,000
General paper mill.	1 ton paper product	19,504.8	29,937.6	780
Straw board.....	1 ton product	5,715.4	151,502.4	2,500
Tanning.....	1 skin	163.3	1,261.0	22
Creamery†.....	100 lbs. butter fat	0.90	7.90	14
Corn products† refining.....	100 bushels			500

* Adopted from table 46, United States Public Health Service Bulletin, No. 143.

† Estimated from a number of analyses.

As a matter of historic interest only, it may be stated that, in the production of one barrel of distillery product, the waste produced is equivalent to the sewage from approximately 50 persons.

Generally speaking, therefore, it is possible to convert the pollution by trade wastes into its equivalent in sanitary sewage and from this figure to determine the required dilution or treatment necessary to prevent pollution. The dissolved oxygen in stream water will vary from approximately 14 p.p.m. at 35°F. to approximately 9 p.p.m. at 70°F., provided the stream is not already polluted and therefore less nuisance is caused by a given amount of sewage in equal amounts of water in winter than in summer.

From the above stated figure of 2204 pounds which represents the daily amount of oxygen required to mineralize the sewage from 10,000 persons, and assuming that 5 p.p.m. of oxygen may be given up by the stream at any time without causing serious nuisance or damage to fish life, it may be estimated that a flow of 80 cubic feet per second or 8 cubic feet per second per 1000 population will be ample for dilution. Such calculations are misleading, however, and cannot be generally applied, since, so much depends on the local condition of the stream. In the past some authorities have stated that a flow of 4 cubic feet per capita is ample, while recently the Royal Commission in England has recommended a dilution of 27.8 cubic feet per second per 1000 persons.

Self purifications of streams is a factor in this problem, but is badly misunderstood. For instance, we have often heard the statement that the Missouri River purifies itself in 7 miles, but this may or may not be the case. Self purification is a factor of time, since certain chemical and biological changes must take place and, therefore, the velocity of the stream, its turbidity, turbulence and other factors must be considered.

Langdon Pearse states that the Illinois River on one test absorbed 205,000 pounds of oxygen from the air while flowing a distance of 65 miles, which fact merely shows that oxygen for self purification can and does come from the air, but this figure cannot be considered for general application, since it represents a certain set of conditions which may or may not be duplicated elsewhere.

Ohio River pollution studies by the United States Public Health Service show that the time of flow from Pittsburgh to the Mississippi River may be anything from 14 to 129 days, depending on the river stages, which fact again emphasizes the point that each instance of pollution is a problem in itself.

This is a very sketchy outline of some of the features of the stream pollution problem, but it serves to show that streams have a definite

capacity for biological disposal of sewage and trade waste and that, if the municipalities, and other sewage or trade waste contributors along the stream, control the amount of pollution which they contribute, by properly designed and operated sewage disposal plants, the streams can be kept in good condition, not only as regards nuisance, but with respect to water supply, fish life and other features.

The solution of this problem is obvious and calls for:

1. Treatment of sewage and trade wastes at their source, to an extent to be determined in each individual case.

2. Maintenance and careful operation of sewerage systems and disposal plants.

3. Purification of water at intakes of water supplies, to the extent necessary for safety.

4. Careful operation of water purification plants.

This requires the determination of the extent of purification needed at both ends of the line and for this information we must rely upon information gotten by the federal and state health authorities, who are doing immensely valuable work along this line, and deserve better support from the public than they have received in the past.

Organizations such as the Isaak Walton League are working toward the return of our streams to their original purity and that the problem is being recognized by legislators is evidenced by laws in nearly every state. It is doubtful, however, if this problem can be solved by legislation alone. The solution will probably come only when the public as a whole realizes just how far its welfare depends on proper protection of our streams. When this occurs, prompt action by local organizations will be taken to the end that the necessary work be done.

EQUITABLE CHARGES FOR AUTOMATIC SPRINKLER CONNECTIONS[1]

By William Cartwright[2]

This is not the first time the question of charges for connection to automatic sprinklers from public mains has been discussed in the meetings of this Association, but so far as I know it is the first time that a large insurance organization like the Board of Fire Underwriters of the Pacific has been privileged to offer you its views on this important subject.

As the Board is an impartial body, and disinterested in the financial arrangements between water companies and their customers, I feel confident it will not be suspected of self-interested motives. On the other hand, I believe the experience of the Board on fire protection in general and on automatic sprinkler systems in particular will qualify it to speak on some aspects of the subject from a different point of view.

It is generally recognized that a public water system has only two major functions, namely;

a. To supply water for domestic and industrial purposes, and

b. To supply water for the extinguishing of fire.

It must also be accepted that, if a water system is to meet fully all its obligations, it must be capable of supplying both these demands.

I think that speakers on this subject have not always recognized the automatic sprinkler system as coming within the latter class, and some rate schedules even make no distinction between connections to serve automatic sprinklers and connections to serve ordinary domestic purposes.

The relation of automatic sprinkler systems to the water system largely hinges on its manner of operation. Unlike most other fire extinguishers it is set in motion by the fire itself and without the aid

[1] Presented before the California Section meeting, October 28, 1926.

[2] Engineer, Board of Fire Underwriters of the Pacific, San Francisco, California.

of any human agency, and it usually happens that the fire is extinguished at its very inception by the opening of one or two heads, and to the accompaniment of a very audible water flow alarm. This almost invariably means that very little water is used in extinguishing the fire, and the water flow alarm ensures the water being turned off the system at the control valve as soon as the fire is out. On the other hand it is safe to say that in the absence of a sprinkler system the fire would not be discovered until well under way, and in the unavoidable delay of getting the fire department apparatus at work it will have reached much more serious proportions. Very often enormous quantities of water are necessary to extinguish the fire, all of which is furnished free of charge.

It is sometimes held that "Readiness-to-Serve" justifies a high annual charge for a sprinkler connection, or that such a charge is proper on the grounds that it confers on the user the advantage of lower insurance rates. Every property owner is entitled to fire protection from the public mains without any cost other than his ordinary contribution to the general tax levy. In the case of private water companies a part of this tax is passed on to them, and in return the water company, whether privately or publicly owned, provides water for fire extinguishment, and street mains of adequate size for the fire demand. The "Ready-to-Serve" feature exists already in the obligation of the water utility to provide water for general fire purposes, and, if a property owner provides, at his own expense, a way of taking the water to which he is already entitled and applying it to the fire through a more efficient and economical means than street hydrants provide, he has contributed no additional burden or expense to the water company, but has on the other hand considerably lessened it.

Neither should the value or benefit to the user be the measure of the charge he should bear. Indeed this argument introduces an entirely new principle, which, if consistently applied, would necessitate schedules based upon the uses all consumers made of the water and the profits they derived from it. It would be improper to deny that the normal condition of any building is one in which all fire hazards are properly cared for, and for which a relatively low insurance rate is, quite properly, charged. An unsprinklered building is a risk in which the owner has neglected to avail himself of the fullest degree of fire protection, and for this abnormal condition he is penalized by being called upon to pay a larger insurance premium than he otherwise would.

It is not always the case, however, that the property owner would, by installing automatic sprinklers, save enough to enable him to pay a large annual charge for the water connection in addition to interest on his investment and an installment to wipe out the capital cost. Indeed sprinkler protection appears to have been developed to the point where most of the plants which show a large insurance saving are already sprinklered. There is, too, a large class where the saving will never pay for the cost of protection, but in between these two there is a very large number of risks where the saving which might accrue is entirely swallowed up by the water works charges, or the residue is so small as to be unattractive to the owner. Risks of this class constitute the large majority of commercial buildings and from a fire loss point of view they contain the most potential hazard both as individual fires and as conflagration starting points.

If then it is conceded that every property owner is entitled to water for fire extinguishment without direct payment for the same, the need for a meter in the water connection is not apparent, and can be justified only as a means of detecting a surreptitious use of water for other purposes than the legitimate and special function for which it is furnished. If this theft of water is taking place it is criminal, and as such is a matter for the police department, and not the water company, to take care of. The remedy does not lie in imposing a general and prohibitive requirement upon every owner of sprinklered property, be he guilty or innocent. Mr. George W. Booth, Chief Engineer of the National Board of Fire Underwriters, has stated

> It is our opinion that sprinkler system services, through which no water is drawn except for use in connection with fire protection, should not be metered. There is normally no draft through them, and we believe that it is possible to prevent the illicit use of water by other and simpler means than the installation of meters. These devices add to the expense and likewise to the friction loss in the supply line; some types of meters also introduce the probability of clogging or entirely cutting off the supply by foreign material which may be in the pipe.

A weighted check valve with a smaller meter in a by-pass, in conjunction with the water flow alarm system of the sprinkler installation, would offer sufficient safeguard against the possibility of water stealing. Frequent inspection of all sprinkler systems is made by insurance organizations and these could, if necessary, be supplemented by independent inspection by the water company at the expense of the property owner. This system has been adopted in some cities and is apparently giving satisfaction.

Apart from the loss an individual property owner may suffer from a fire, I think there is another and larger aspect of the case we should consider. A fire is a large irrevocable loss to the whole community. Our own insurance premiums will have to be kept high enough to enable the insurance companies to reimburse the owner, and the municipal and state taxes which he formerly paid will have to be made up by the rest of us. A destructive fire will cause large plants to close down or perhaps go out of business and leave their employees without means of livelihood. The owner of sprinklered property has materially decreased the likelihood of such a catastrophe. Labor will benefit by its greater assurance of continuous employment. The danger to human life will be diminished. Fire departments will be relieved of a large portion of their arduous work, and less demand will be made on the public utility providing water. He ceases to be a serious fire exposure to the surrounding property, for it is a fact that a conflagration never started in a sprinklered building; and he has set up a fire break or conflagration barrier in the event a fire has started elsewhere in the neighborhood. New York is considered by experts a city immune from conflagrations on account of the barriers set up by sprinklered buildings.

I mention these incalculable public benefits to be derived from sprinkler protection, because I believe that this status of the automatic sprinkler is a most important factor and justifies its recognition as in a class entirely distinct from industrial or domestic uses of water.

The recent publication by the National Board of Fire Underwriters of the fire losses in America for 1925 brings me to the last point on which I will ask you to hear me. Over 570 million dollars of property and thousands of lives were sacrifices to fire. It is to be expected in the natural course of events that there should be an increase in our fire losses. New processes in the manufacture and handling of the goods which serve the changing needs of our civilization have increased enormously the fire hazards attending them. Gasoline for instance was, only a few years ago, a by-product in the manufacture of kerosene, but is now in general use for many industrial purposes, and has increased the fire waste tremendously.

If we conscientiously strive to prevent these increasing hazards from making further additions to the annual fire waste, we must make it a matter of public duty to help in discouraging any condition which tends to destroy the interest of the property owner in equipping his building for the reduction of the fire peril.

The Pacific Coast Association of Fire Chiefs at its annual meeting last year expressed its feeling on this subject by passing the following resolution

WHEREAS this association is of opinion that automatic sprinklers are a public benefit, in that they have proved to be an efficient means of fire extinguishment and in that they tend to conserve human life, wealth and property from disastrous fire, and

WHEREAS it is believed that an automatic sprinkler system does not increase the demand on the public utility providing water, but instead tends to decrease it

IT IS THE DESIRE of this Association to encourage the installation of automatic sprinklers, and to discourage high monthly charges for connection from public mains to automatic sprinkler systems, provided the individual or individuals receiving this service assume the entire cost of the installation and maintenance of the connection.

High charges for sprinkler connections are a serious deterrent to the enterprise of property owners in making proper provision for the safety of their premises, and our attitude to this question will largely be the measure of our conception of the ideals of good citizenship.

IRON REMOVAL PLANT AT SELMA, ALABAMA[1]

By J. A. Fulkman[2] and E. J. Taylor[2]

The City of Selma, Alabama, has a population of 18,000. The water works system is owned by the city and operated by a commission elected by the city council. The railroads and practically all of the industries have their own wells, so that the public supply is used almost exclusively for domestic purposes.

For a number of years the consumers have been annoyed by "red water." In November, 1924, the water works commission decided to have an investigation of the underlying cause of this trouble, and what could be done for its elimination. This disclosed that the iron in the water which was causing the trouble could be removed by aeration, sedimentation, coagulation and filtration through rapid sand filters. The construction of a plant of 1,500,000 gallons daily capacity was started in September 1925 and operation commenced in May 1926. The description of these works follows.

SOURCE OF SUPPLY

The water is obtained from artesian wells. The main supply being a 10-inch well, 450 feet deep. The water level under continuous pumping is about 30 feet below the ground surface. A Worthington "Axiflow" pump, directly connected to a 50-horse-power electric motor is used to pump this well. This pump is controlled by a float switch connected to the settling basins. It discharges 1,250,000 gallons per day against a total head of approximately 40 feet, or sufficient to carry the water through the new plant. There is also an auxiliary and emergency supply consisting of five 6-inch wells; which are also about 450 feet deep. These are pumped by air lift; the compressor being operated by steam. The combined discharge of these wells is 1,500,000 gallons per day.

The water, when pumped from the wells, is clear and is safe for drinking, but contains 18 parts per million of free carbon dioxide and

[1] Presented before the Central States Section meeting, September 22, 1926.

[2] With Morris Knowles, Inc., Engineers, Pittsburgh, Pa.

2 parts per million of iron. When this water is exposed to the air the soluble iron compounds are oxidized and the water becomes cloudy and brownish in color. It also stains the plumbing fixtures and forms a sludge in the mains which has caused considerable dissatisfaction.

SPRAY NOZZLE AERATORS

Spray nozzle aerators are connected to the raw water lines from the wells. Two sets of nozzles are provided, each set consisting of eight 2-inch "Sacramento" nozzles, manufactured by the Water Works Supply Company of San Francisco, California.

Each nozzle is designed to deliver 75 gallons per minute with a 5-foot loss of head. They were found to give an efficient and satisfactory spray with as low as 3-foot head. The water from the nozzles falls on a slightly inclined concrete slab and flows to the influent end of the settling basin.

SETTLING BASINS

Two settling basins are provided; one under each set of nozzles. Each basin has a capacity of 190,000 gallons. This gives a combined capacity of 380,000 gallons and a retention period of about six hours, at the normal rate of 1,500,000 gallons per day. This settling period may be somewhat longer than necessary, but was provided on account of remodelling an existing reservoir for settling purposes. An around-the-end-baffle is provided in each basin. A velocity of 0.25 foot per minute is maintained when operating at the normal rate. The piping is so arranged that the basins can be operated separately or together as desired. High pressure lines and hose valves and drains are provided for cleaning the basins.

MIXING CHAMBERS

Although the preliminary experiments indicated that satisfactory results could probably be obtained by aeration, sedimentation and filtration only, it was deemed advisable to provide for the addition of lime and alum or iron sulphate. Two dry feed machines are located on the second floor of the control and chemical house. Each machine is so connected that it will feed to the two mixing chambers, located on the first floor of this building.

The mixing chambers are circular concrete tanks 10 feet in diameter and 10 feet deep, giving a mixing period of ten minutes at the normal

rate of 1,500,000 gallons per day. Mechanical agitators are provided, consisting of a vertical shaft directly connected to a one horse power motor, making 860 revolutions per minute. Two 11-inch, two-blade propellers are fixed to the shaft. The bottom propeller, located five feet above the tank floor, deflects the water upward, while the other propeller, located 6 feet above the tank floor, deflects the water downward. The influent pipe is located 1 foot above the floor of the chamber and the effluent pipe is on the opposite side of the tank 5 feet above the floor. This arrangement proved satisfactory, the agitation being quite thorough throughout the tank. The chemical treatment, if and when used, is to be applied after sedimentation. It was therefore necessary to provide coagulation basins ahead of the filters. Provision is also made for taking the raw water from the wells directly to the mixing chambers, thence to the settling basin as in the ordinary filtration plant.

LIME BASINS

There are two coagulation or lime basins provided. Each basin has a capacity of 35,000 gallons, giving a detention period of 1.1 hours at the normal rate of 1,500,000 gallons per day. Wooden over and under baffles were installed in these basins to give a velocity of 0.1 foot per second. When the mixing chambers and coagulation basins are not used the settled water can be taken directly to the filters.

FILTERS

Three one-half million gallons per day filter units were installed in a separate building. The filters are reinforced concrete boxes, 15 feet by 12 feet by 9 feet deep. The under drainage system consists of a 12 inch by 18 inch concrete flume, built under the filter floor, in which are inserted 2½-inch by 2½-inch by 3½-inch cast iron tees, 7 inches on centers. Cast iron laterals, 2½ inches in diameter, with ¼-inch holes in the bottom, 45 degrees from the vertical, extend across the filter from these tees. They are placed 1½ inches above the filter floor and the wall ends are set in cement grout.

The filter bed consists of 18 inches of gravel, graded from 1¾ inches to $\frac{1}{12}$ inch in diameter, overlaid with 30 inches of sand, having an effective size of 0.37 mm. and a uniformity coefficient of 1.7. The high uniformity coefficient was allowed because the precipitate was

fine. All filter valves are hydraulically operated from operating tables on the operating floor above the pipe gallery. Venturi type rate controllers are used, with indicating and recording rate of flow and loss of head gauges mounted on the operating tables.

The wash water troughs are reinforced concrete, placed 24 inches above the sand. The wash water is supplied from a 40,000 gallon elevated steel tank, at a pressure varying from 22 pounds per square inch to 15 pounds per square inch. This gives a maximum rise of 24 inches per minute in the filters during washing. The preliminary operation indicated that best results were obtained by washing the filters when they showed a loss of head of about 6 feet. Each unit would filter about one million gallons and requires about 20,000 gallons for washing. Thus only 2 per cent of the water filtered is used for washing.

RESULTS OF PRELIMINARY OPERATION

The plant was first operated with water from the electric-pumped well, using aeration, sedimentation and filtration only. The raw water contained 18 parts per million of free carbon dioxide and 2 parts per million of iron. The free carbon dioxide was reduced to 6 parts per million in the aerators. After sedimentation the free carbon dioxide content was found to be 3 parts per million and the iron content 1.1 parts per million. The precipitate was fine, being practically invisible to the naked eye. However, it failed to pass the filters and the filtered water showed 3 parts per million of free carbon dioxide and only 0.25 part per million of iron.

When the plant was operated with the air lift wells the reduction of free carbon dioxide was practically the same and the reduction of iron in the settling basin was also the same. However, the filtered water showed only 0.15 parts per million of iron. This was attributed to the better aeration. It was found that the free carbon dioxide was down to 3 parts per million at the aerators against 6 parts per million for the electric pumped well.

The plant was also operated with the addition of lime after sedimentation, to completely remove the carbon dioxide. This was added at the rate of 15 pounds per million gallons per part per million of free carbon dioxide. Since there were 3 parts per million of carbon dioxide present after sedimentation it required 45 pounds of lime per million gallons. There was no appreciable reduction of iron in the coagulation basin, but the filtered water showed the

carbon dioxide removal to be complete. The iron content was only 0.06 part per million. The alkalinity to phenolphthalein was only 4 and to methyl orange 80. The alkalinity to methyl orange in the raw water was 79.

An iron content of 0.25 part per million and a carbon dioxide content of 3 parts per million was considered satisfactory. The filtered water was found to be non-corrosive, giving pH 8.6. The plant is therefore operating with aeration, sedimentation and filtration.

There was at first considerable doubt among the citizens concerning the plant. Some did not think it would work and others expected to find the water "flat" for drinking. The plant was therefore first operated without an announcement. After six hours the difference could be plainly seen in the tap water and in three days everyone was remarking about the clear water. Plumbing fixtures once cleaned stayed that way—shower bath curtains failed to turn red the second day they were used and no one found the water flat. At the time of the inspection by the Mayor and Council the latter part of May it was unanimously decided that it was the best $65,000 the City of Selma had spent in years.

The report by H. G. Menke, of the Alabama State Board of Health, made after preliminary operation, contained the following:

> The deferrization plant of the City of Selma is very complete and flexible. Every possible foreseen operation has been provided for, so that almost any condition of water may be satisfactorily treated. The adaptation of new work to old was nicely accomplished and the plant presents a pleasing appearance.
>
> Selma's water supply has been unsatisfactory from a physical standpoint because of iron. With the new work completed no further trouble should occur from this source. The water with good operation of the plant should always be clean and sparkling and practically free from iron.

The writer visited the plant the latter part of August and it was then producing a very satisfactory water. The foreman of the distribution system stated that they did not have any further trouble with the water running rusty for several hours after opening a main for repairs or additional connections as they had before the iron removal plant was put into operation.

The Smith Company, of Birmingham, Alabama, were the contractors for the structural work; the McFarland Engineering Company, of Kansas City, Mo., for the filter equipment; and R. D. Cole Company, of Newman, Ga., for the wash water tank. E. J. Taylor

was resident engineer for Morris Knowles, Inc., during the construction of the plant. Albert Thalheimer is President and Robert Coleman, Manager of the Water Works Commission. Much credit is due them for the short time that elapsed between the investigation as to what should be done to eliminate the "red water trouble," and the completion of the iron removal plant.

THE FRANCHISE OF THE CITIZENS WATER COMPANY, BURLINGTON, IOWA[1]

By Francis D. H. Lawlor[2]

The Burlington Water Company was incorporated for a period of twenty-five years in 1877. The first water ordinance was adopted by the City Council July 17, 1877. It provided that the cost of the water works should not exceed two hundred thousand dollars and that the plant should be in full operation within one year with 10 miles of water mains and 150 fire hydrants; that the works have a capacity of three millions gallons daily and be capable of throwing six streams to a height of 75 feet through inch nozzles on the high ground or eight streams through inch nozzles to a height of 100 feet on the low ground.

The capital stock of the company was fixed at three hundred thousand dollars, not more then 10 per cent to be paid up at that time. A bond issue of two hundred thousand dollars was authorized and an annual dividend of 12 per cent on the paid up stock was allowed.

The City had the option to purchase the plant by giving a year's notice in writing at the beginning of any year. This right was not exercised until the franchise of the water company expired in 1902.

The plant was originally built by the Holly Manufacturing Company and had one Holly quadruplex pumping engine of three million gallons daily capacity. Extensions of mains were made from time to time during the life of the franchise. In 1902 the Company had about 22 miles of cast-iron mains. About 1884 a second pumping engine, a Holly Gaskill of three million gallons capacity was installed. In 1893 and 1894 a larger Holly Gaskill of six million gallons daily capacity was purchased, a filter house was built and the original type of Jewell gravity filters were placed therein. The filtered water was stored in a masonry basin below the filters.

Strained relations existed for many years between the Burlington Water Company and successive City Councils.

[1] Presented before Iowa Section meeting, November 4, 1926.

[2] Superintendent, Citizens Water Company, Burlington, Ia.

When the franchise expired in 1902 the City, not being in a position to finance the purchase of the plant, a number of citizens organized the Citizens Water Company to accomplish this object.

The ordinance of the Citizens Water Company was approved and accepted October 10, 1902. It was found the City had acquired sixty-five thousand dollars of the bonds of the Burlington Water Company. In lieu thereof it was given that amount of the common stock of the new Company.

During the years that have elapsed since 1902 the City has taken its six per cent dividends on this common stock and reinvested them in the securities of the Citizens Water Company. To-day it holds about one hundred and seventy or one hundred and eighty thousand dollars of the stock or bonds of the Company.

Policemen and firemen pension funds have also been invested in the same securities.

Section 4 of the ordinance provides that the Company may be required to extend its mains along graded streets provided the revenue is sufficient to pay 6 per cent annually on the cost of the work.

If the Company is required to extend its mains along streets that are not at grade the City pays the cost of lowering the mains when the streets are graded.

The extension of mains required is limited to 3 miles each year for the first and second years and to 2 miles each year thereafter.

Under this provision of the ordinance the distribution system has grown from the original 10 miles of mains and 150 fire hydrants to 65 miles of mains and 630 fire hydrants.

In recent years our difficulty has been to find streets that will pay the 6 per cent interest on the present costs for our water rates are much the same as forty-nine years ago.

During the last few years we have introduced a form of contract to enable contractors or promoters to have water mains laid in new additions by guaranteeing the 6 per cent revenue for a term of ten years and by depositing Liberty Bonds or cash to secure the guarantee. We give the guarantor an accounting each year and deduct the deficit each year from his guarantee fund.

Whenever the street pays the 6 per cent we refund the balance of the guarantee fund and close out the account. In a few instances we figured the guarantee fund too low or to speak more correctly we overestimated the annual revenue the street would pay.

Under section 9 the City levies a five-mill tax on the dollar on all the property, real and personal, in the established water district. This tax now yields in round figures twenty-eight thousand dollars per annum. The interest on the bonds of the Company, which is guaranteed by the City, is the first claim on this tax. The proceeds of the five-mill tax go to the treasury of the Water Company and constitute the payment by the city for water supplied for fire protection, for flushing sewers and other public uses for which City does not pay in any other way.

Section 10 fixes the capital stock of the Company at three hundred and thirty thousand dollars, viz., $150,000.00 common stock carrying 6 per cent dividends payable semi-annually and $180,000.00, preferred stock allowed 5 per cent dividends, also payable semi-annually. The preferred stock may be retired.

A bond issue of two hundred and twenty thousand dollars was authorized, but only one hundred and eighty thousand dollars of the bonds were sold and of this amount sixty thousand dollars were purchased during the world war and placed in the Treasury for emergencies.

Section 14 provides the City may purchase the water works by giving a year's notice in writing, by buying the stock at par and by assuming all the other liabilities of the Company.

Section 16 provides for a board of five directors two appointed by the Mayor and three elected by the stockholders each year.

Section 18 provides for arbitration between the City and the Water Company in the event of disagreement.

Section 19 requires semi-annual reports of all receipts and expenditures to be made to the City.

Section 21 provides that the Company may fix its own rates, but no such charges shall be greater than shall be found prevailing in some of the cities of Des Moines, Davenport, Muscatine, Clinton or Cedar Rapids in this State.

We now have 6970 active services of which only 450 are metered. Burlington is a flat rate city with a population of 26,200 and a daily consumption of about 105 gallons per capita.

The relations between the Water Company and the City have been very amicable during the past twenty-four years. The public realize that no salaries are allowed except those of the Secretary and the Superintendent and their subordinates, that no Director or stockholder of the Water Company can receive anything more than the

regular dividends allowed by the franchise and that all surplus monies accumulated are spent on the improvement of the plant.

The proceeds of the bond issue were used in making improvements needed immediately after the organization of the Citizens Water Company. Since that time approximately fifty thousand dollars has been spent annually on extensions, improvements and betterments, all of which have been made from earnings.

Alvord & Burdick made an inventory and report upon the value of the properties of the Water Company as of January 1, 1916, basing their figures on an average cost of labor and materials over a term of years previous to 1916. They placed the value of the property as of that date, in round numbers as nine hundred and sixty thousand dollars, exclusive of operating capital. Their figures were based on prewar prices. During recent years the expenditures on capital account have been much greater than the depreciation.

Looking back over the twenty-four years since the organization of the Company, we believe we can truthfully say the ordinance has considerable merit and that it is one way to attain the advantages of municipal ownership in combination with those incidental to private management.

Whatever success has been attained in Burlington may be attributed to the hearty coöperation of the City and to the fairness and public spirit which has animated both parties to the contract.

DISINFECTION OF NEW WATER MAINS[1]

By William W. Brush[2]

It has been our practice for a great many years to require a certain amount of hypochlorite of lime to be placed in the pipes as they are laid. The requirements specified for cleaning pipes and for chloride of lime read as follows:

7: Cleaning pipes, etc. All straight pipes and special castings shall be cleaned by brushing and by thoroughly washing out all dirt or all foreign material before laying. To prevent any foreign matter entering the main as the pipe laying proceeds, if the engineer so directs, a proper mandrel shall be provided by the contractor which shall be drawn forward as each pipe or special casting is laid. All branches and other openings shall be stopped up by wooden plugs or heads until either connected or capped.

8: Chloride of lime. As each length of pipe is laid, the contractor shall furnish and deposit in each length one-half ounce of chloride of lime. The contractor shall furnish and place said chloride of lime, the cost of same to be included in the prices bid for laying pipes. Instead of placing the chloride of lime in each length of pipe, the contractor may deposit same on each side of the valve in the main line in a sufficient quantity for the length of pipe between valves.

You can readily see the way in which it is expected that this chloride of lime will act in sterilizing the main. After the main has been laid between two valves, a valve at one end is opened to let the water pass into the main and over the chloride of lime which is dissolved and sterilizes the main. After the main is filled, it is thoroughly blown out and a sample of the water taken and sent to the laboratory to be examined for the bacterial contents. Usually we find that only one blowing out of the main is necessary to get a water that is satisfactory, but at times we have had to blow out a main three or four times, and after each time it was blown out a sample was sent to the laboratory. As near as I can determine the additional blowing off of the main is due to the accumulation of mud in the pipe, as the chlorine will not effectively sterilize below the surface of the sediment

[1] Discussion presented before the Buffalo Convention, June 11, 1926.

[2] Deputy Chief Engineer, Department of Water Supply, Gas and Electricity, New York, N. Y.

that is in the main. Just to what extent the sterilization will take place below the surface of sediment I do not know, but from experience during the past year I am inclined to think that the chlorine penetrates only slightly below the surface. It appears therefore that it is very important that the surface of the pipe should be free from any accumulation of sediment when the pipe is laid, and if that be the case a very small amount of chlorine will be all that is necessary to sterilize the interior of the main. Fortunately the sediment that gets in the pipe is usually of a character that is not likely to be detrimental to the health of human beings, but it is not a pleasant thought to lay pipes and put water through them and send the water to the consumer if the water comes in contact with what we would commonly term filth.

A year ago we had to lay a pipe in the Rockaways just before the opening of the summer season. It went through the only street that was paved for automobile traffic, so that if the work continued into the relatively short summer season, it would seriously interfere with the business season of the merchants and hotel men in the Rockaways, the Rockaways being part of our borough of Queens, and the southeastern corner of the city of New York. Our contractor had a twenty-four inch main to lay, and for the greater part of the distance it was below the water level in a sand which was virtually very fine beach sand. The sewer system was noted more for the openness than for the tightness of its joints, with the pipes only about four feet below the surface. As a result when the tide rose, the sewage backed up in the pipe and in part seeped out and polluted the sand in the vicinity. When the tide fell the sewage again flowed out into the bay or ocean. We therefore had a polluted sand and a polluted ground water, and it was impossible to get the trench free from water, so that the water pipes were at times completely immersed in a polluted water and quite a good deal of polluted sand was washed into the pipes.

After the pipes were laid and tested the volume of water available was not sufficient to blow the sand out because one part of our connecting line to the city system was not completed and we could only take a small amount of water from the local company. We added chlorine gas to the water flowing into the main until we had three parts of residual chlorine per million in the water at the further end of the pipe line. That high chlorine content water was held in the pipe line, as I recall, for some twenty-four hours, and then flushed

out, and we thought that we would have a reasonably safe line. We sent a sample to the laboratory and got a satisfactory report, although the water was not quite as good as we would like to have had it, and we started to use the line. Within a day or so we had complaints of tarry taste due to the chlorine attacking the coal tar coating, and, what was much more disturbing, the laboratory reported the bacterial content to be high. The line was immediately shut off and it was found that it was impossible to get that line safe to use until we could use the city supply and flush it out with a velocity of six or eight feet a second. Even with that velocity we had to flush it out three times running for several hours each time before we could get the sand out of the pipes, and the joints in the pipe, sufficiently to give us a sterile line after chlorination. In order to get that high velocity, we had to open up a thirty inch branch to the bay, and let the thirty inch branch deliver at full flow during the time we were washing out the main. That experience brought home to us very, very strongly the fact that you cannot have polluting material in your pipe and be safe in using that pipe, because you cannot get the chlorine to penetrate the material that is in the bottom of the pipe. I am glad to be able to bring this experience to you, believing that if you ever have a similar situation our experience may save you the very uncomfortable days that we had after we knew that pipe line had been used and later found to be in an unsatisfactory condition. As a matter of fact, there was no illness that could be attributed to the use of that pipe except some slight stomach disturbances.

DISCUSSION

MR. LANE: I want to ask about the quantity used; was it half an ounce per length? Was that right?

WM. W. BRUSH:[2] In our regular specifications, which cover usually pipe up to 12 inches, it is half an ounce of chloride of lime to each length.

MR. LANE: Does it make any difference regarding the size of the pipe?

WM. W. BRUSH:[2] It probably would, although my recollection is the half ounce gives a pretty high chlorine content to the water.

B. C. LITTLE:[3] I am anxious to know what led you to sterilize your mains and how long you had been doing this? I will have to confess that we have never done it in Rochester. From the experience you know of in other cities, has there been such sterilizing of the mains?

WM. W. BRUSH:[2] My recollection is that we started about twenty years ago. We started because it seemed to us that a pipe that has been lying on the street without any protection for possibly a period of several weeks or several days, is not a clean utensil for a conduit through which to pass water that is to be used for drinking. We first started to put in the chloride of lime and blow out the pipes without sending the samples to the laboratory. Then we concluded that it was not very reasonable to do it somewhat blindly when we had our laboratory there and we started the practice of sending the samples to the laboratory. Our experience has indicated the desirability of so doing, because it has shown us the cases where we did not get satisfactory results. It has been the cause, I believe, of more care on the part of our construction group in looking after the cleaning of the mains as they are laid.

The pipe should be clean when the water passes through it to the consumer and we know it is not clean as it lies in the street. We ought to wash it out thoroughly, and it only seems a reasonable precaution to put a sterilizing agent in that pipe before we let the water reach the consumer.

B. C. LITTLE:[3] You have not answered one question I meant to ask; have you any statistics as to the custom in other cities?

WM. W. BRUSH:[2] I personally do not know that I can answer with any certainty as to the custom. I have had it brought to my attention that some other cities do follow a practice somewhat similar to ours, but I could not at the present time name those cities. I would be glad to have those present indicate to us, assuming we do have those present who blow out the mains before they put them into service. I will ask them to please raise their hands. Well, there are quite a number who do that. Now, how many put any sterilizing

[3] Secretary, American Water Works Association, Rochester, N. Y.

agent in? There are two, Mr. McDowell and Mr. Lane, of St. Petersburg, Fla.

MR. LANE: While you are having your laboratory samples tested, do you put the main into service or leave it out of service until after you get the report?

WM. W. BRUSH:[2] We leave it out of service until after we get the report. If we are replacing a main and there is no way of avoiding the immediate use of the main, we blow thoroughly and put it into service, but when we are extending mains, we leave them out of service until we get the laboratory report that the water is satisfactory. If it is not satisfactory, we blow the main again. We do not try to sterilize a second time, other than in unusual situations such as described for the Rockaways. After the first introduction of chloride of lime, we depend upon blowing and the removal of any sediment in that manner.

PHIL CARLIN:[4] Do you have any specified time for this water to remain in the mains before it gets into the general system?

WM. W. BRUSH:[2] No, Mr. Carlin, usually it is an extension of the system and therefore the water would not go into the general system; it would go to the building to be connected. It takes our laboratory forty-eight hours before they are willing to give a report, because of the usual three day test for B. coli, but if the laboratory gets a negative on twenty-four and then again a negative on forty-eight hours, and there is any need to hurry up a little on putting the main into service, we open up the main for service.

MR. LANE: We began the chlorinating of the pipes about a year ago. We were led to do that because ours is a very flat country and a good part of it had no sewers in it. A great many septic tanks were in use, and in putting in these new mains, it seemed possible, especially in going through muck land, that the mains would be so contaminated that the water would not be fit for use, so we thought it was best to use lime. We let the water stand twenty-four hours until our local sanitary board has examined it, and if that examination is satisfactory, the pipe is put into service.

[4] Superintendent, Water Works, Sioux City, Iowa.

H. P. BOHMANN:[5] I was wondering how you insert the hypochlorite if the line needs a second treatment, after you have blown out the line and find it necessary to give a second application?

WM. W. BRUSH:[2] We used the liquid chlorine, and we insert it through a tap in the main. There is a small portable machine that was made up by Wallace & Tiernan Company that we have used. The details of that machine I do not know, as I have never seen it actually in operation in the field. I do not recall any of my men explaining to me exactly the details of that machine, but it is a small portable machine and we had to guess somewhat at the rate at which the chlorine was going in. What we do is this, we take water at the nearest hydrant and test for residual chlorine and then we set the flow of chlorine so as to get at least as high as we have fixed as the minimum free chlorine. In the case of the Rockaway main we had three parts of free chlorine at our furthest hydrant and we had five parts at the hydrant nearest the point of introduction of the chlorine. The furthest point was a couple of miles away. Still it was evidently only the surface of the sand that was sterilized by that strong chlorine treatment, as within about two days, the bacteria in the sand had worked up to the surface and the water that was drawn showed in some places as high as 500 bacteria. That result was after the chlorinated water had been drawn off and other water introduced at a rate which probably did not disturb the sand, because we tried to keep the flow down to the point where it would not disturb the sediment left in the pipe. We intended to use this pipe only temporarily to meet a very serious shortage of pressure, and had planned to blow it out thoroughly as soon as our own system was available, but we had to cut it off and leave it off until we could get our own flow through the pipe.

MR. MCDOWELL: Such a condition as Mr. Lane had prompted us to use hypochlorite of lime for sterilizing new mains and old mains that were replaced by new mains. Charleston has low lying ground. In some portions of the city it is necessary to wait until low tide to lay the mains. With the tide coming in and flooding the mains in course of construction, it brings the filth into the mains. Therefore, we started sterilizing the mains.

[5] Superintendent, Water Works, Milwaukee, Wis.

L. H. ENSLOW:[6] The research work being done by the Chlorine Institute on chlorination of sewage confirms exactly your supposition that the bacteria are protected. Chlorine, we find, will not penetrate a solid body. Therefore, it is not to be considered efficacious in the presence of large particles of solid matter. It seems that the outside surface of the solids are seared by the chlorine, and whether or not a protective coating is formed I do not know, but in some water a protective coating forms on the surfaces and the chlorine does not thereafter penetrate. The only way to carry on effective disinfection of solid masses is to create such velocity that it will break those masses up or else get rid of them.

While I am here I might mention a very effective method used in Texas on wells which a company there now drill, and where a combination graval pocket is formed around the strainer in the bottom of the well. The well people had quite a bit of trouble with the bacteria on the new wells. They have found that the only remedy which has been efficient has been a thorough washing of the gravel with clear water and thereafter they get very satisfactory results from the effluent of the well and no B. coli have appeared. That was discovered in Houston, Texas, and I understand now that it has been adopted as a universal practice.

WM. W. BRUSH:[2] There is one condition to which I should like to call your attention, which you may or may not have experienced. When you shut down a main and blow off, especially with one of the larger mains, where you use a blow off, probably at the bottom of the pipe, it may be blowing off into a drainage channel that may later fill up if you have a heavy storm. You may get polluted water coming back into your main in that way, or you may have a leak in a pipe and make a shutdown to make a repair, and before you make the repair, you may have a similar situation. Those conditions have been brought to my attention, not alone in our system, but also in the systems of some other municipalities. It is very important, therefore, to keep in mind that, when the main is shut down, there is a possibility of water entering if there is any opening left unguarded. That water may be polluted and at least there should be thorough blowing off of the main. If you think that the water that has entered has been seriously polluted, there ought to be also the steriliza-

[6] The Chlorine Institute, New York, N. Y.

tion of the main before it is put back in service. You see we cannot tell by typhoid alone as to whether we are furnishing people with water that is unsafe and unsatisfactory, because it is possible that we will only have the intestinal disturbance that comes from other bacteria and will not happen to have any typhoid bacteria in the polluting material in the water that has entered the pipes. As we reach a higher and higher standard for the purity of our water supplies, we are thereby decreasing the amount of intestinal disturbance among our consumers.

QUESTION BOX SERIES[1]

CEMENT-LINED PIPE

PHILIP BURGESS:[2] It is a well established fact that tuberculation of pipe lines may be an important element affecting the history and efficiency of distribution systems. Any protective covering which tends to reduce, or eliminate, tuberculation of pipe lines is an important asset insofar as it tends to prolong the useful life and efficiency of a water works distribution system. The common method of attempting to preserve the usefulness of cast iron pipe has been to apply some form of tar or protective coating which may, or may not, be effective, depending upon the chemical characteristics of the water carried in the pipe line system. Experience has shown that such protective coverings are not effective in reducing or eliminating tuberculation of pipes, particularly where the water is soft and highly colored. In the case of such supplies, the pipe lines frequently become obstructed by tubercles which may reduce the carrying capacity of the pipe system by from 20 to 50 per cent within a short period of time. Furthermore experience indicates that, in many instances, the cleaning of such pipe lines is not satisfactory, because, after such cleaning, the tuberculation may form again very rapidly so that all value of the cleaning may disappear in a few weeks. This has been the somewhat universal experience of protective coatings on pipe lines carrying soft highly colored water until the last three or fours years when consideration has been given to the use of cement lining to protect cast iron pipe, where the water is of a character that may cause even a small amount of tuberculation in the pipe lines.

The early history of cement lining for pipe indicates that such linings were used first to protect the inside of wrought iron pipe. Experience indicates that such linings were effective both in reducing tuberculation of the pipe and in increasing the life of the pipe, except in such instances as the pipe was attacked from outside agencies.

[1] Presented before the Central States Section meeting, September 21, 1926.
[2] Consulting Engineer, Columbus, Ohio.

About three or four years ago, the method of applying cement linings to cast iron pipe was very much improved by the use of a centrifugal process. By this process the pipe containing the liquid cement mortar is spun at a comparatively high velocity with the result that the cement lining is very compact and clings tenaciously to the inside of the pipe. No other protective coating is used inside the pipe except the cement mortar. The thickness of the lining is greatly reduced by the centrifugal process and varies from $\frac{1}{16}$ inch thick for the 4- and 6-inch pipe to $\frac{3}{16}$ inch thick for the 20- and 24-inch pipe. The surface of the lining is very smooth and hard and experience indicates that no especial care in handling the cement lined pipe is necessary in order to avoid damage to the lining. The cost of lining the pipe with cement is from approximately 8 per cent for the 6- to 12-inch sizes to 6 per cent for the 16- to 24-inch sizes, in addition to the cost of the unlined pipe.

As previously stated, the cement linings which have been in use for some time have proven very satisfactory because they have protected the pipe and because they have appeared to eliminate tuberculation and thereby to maintain the carrying capacity of the cement lined pipes. Owing to the fact that the modern centrifugal process of cement lining is only about three years old, there is, of course, no experience extending over a considerable period of time to show whether or not the benefits to be derived from such linings are of a lasting nature. The best available evidence as to the merits of cement lining probably is contained in an article by Charles W. Sherman (Journal of the New England Water Works Association, vol. xl, no. 1) entitled "Cement Lined Cast Iron Pipe." Mr. Sherman's article contains a brief statement as to the known history of cement lined pipe together with specifications for lining the pipe and a statement of the present cost of the lining. An appendix to this paper contains a report by J. E. Gibson, Manager and Engineer of Water Works Department, Charleston, South Carolina, in which report Mr. Gibson sets forth the results of his experiments to determine the coefficient "C" in Hazens and Williams formula for cement lined pipe. In this report are shown the results of three tests of cement lined pipe, two of which were 6-inch diameter and one was 16-inch diameter. In all three tests the value of the coefficient "C" was higher than that commonly adopted for new cast iron pipe covered with the usual protective coating. The results of Mr. Gibson's tests are of interest and seem to indicate clearly

that cement lining applied by the centrifugal process increases the carrying capacity of the new pipe as compared with the usual protective coating.

At the conclusion of Mr. Gibson's report he states as follows:

> Our experience, covering a period of about three years, shows that the pipe is not incrustating or tuberculating, the carrying capacity is being maintained, and no difficulty is being experienced in tapping or cutting the pipe. A number of Smith taps have been made where the section cut out by the cutter permits of examination, showing that the cement-lining is tenaciously adhering to the cast iron without tuberculating or rusting underneath the coating.

The writer has sent out a number of inquiries to men in the water works business who were familiar with the use of cement lined pipe and, in each instance, the replies received indicate that it is the general experience that cement lining increases the carrying capacity, not only of cast iron pipe, but also of wrought iron pipe, and that furthermore the cement lining eliminates tuberculation which may be expected to form on the inside of pipes carrying soft colored water. In fact there seems to be developing a pronounced opinion among water works engineers that cement lined pipe should be used wherever the water carried is of a kind that may cause even a moderate amount of tuberculation. Present evidence indicates that cement linings increase the carrying capacity of cast iron pipe when new and tend to reduce, or eliminate, tuberculation which might be expected in time were such pipe lined with the usual protective coatings. There seems to be very good substantiating evidence that these conclusions will be confirmed with continued long time use of the cement lined pipe. We may safely conclude that the benefits to be expected from the cement lining of pipe carrying water which may cause even a small amount of tuberculation more than justify the cost of securing this protection.

CONSUMERS REACTIONS TO VARIOUS SYSTEMS OF RATES

J. H. SIMPSON:[3] Probably I can best make myself understood by describing conditions in rates as they exist at the South Pittsburgh Water Company's plant. The company was chartered in 1904 for the purpose of taking over several small water companies purchased at that time by the old American Water Works & Guarantee Co.

[3] Treasurer, South Pittsburgh Water Company, Mt. Oliver Sta., Pittsburgh, Pa.

At that time there was in use a rate system under which the consumers contracted annually beginning April 1st of each year for the quantity best suited to their needs (I am speaking mostly of the small or domestic consumers). This schedule was as follows:

40,000 gallons per year $15.00, all water over 40,000 at 33⅓ cents per 1,000 gallons.
60,000 gallons per year $20.00, all water over 60,000 at 30 cents per 1,000 gallons.
100,000 gallons per year $30.00, all water over 100,000 at 25 cents per 1,000 gallons.
180,000 gallons per year $45.00, all water over 180,000 at 20 cents per 1,000 gallons.

We collected the quarterly minimum in advance and made no extra or excess charges until the quantity of water used exceeded the amount contracted for annually. This meant that a 40,000 gallon consumer might use all of the 40,000 gallons in the 3 quarters ending January 1, but no charge for overage or excess would be made until April 1, at which time all of the water used would be charged for at 33⅓ cents per thousand and we would still be billing at the same time the $3.75 quarterly minimum. This created a goodly amount of complaint from the consumers, for many of them could not see the reason for paying the $3.75 if we charged for all the water used in that quarter at the excess rate. They lost sight of the fact that they had used 40,000 gallons, but paid for only 30,000.

This rate schedule ran along until 1920. The company had carried on all during the war period at the old rates with the vain hope that costs would come down after the war and we could make out some way even with the war shrinkage in our net receipts. When the company finally decided that it would have to raise its rates, on account of so much complaint from the consumers about the system I have just described, it was also decided to adopt what is considered the most modern and up to date system of a "ready to serve" charge plus a smaller meter rate. It was decided that a 20 per cent increase would be sufficient at the time and the new rates were put into effect August 1, 1920. It was later found that the new schedule brought us about 17 per cent increase.

This ready to serve system was new in the Pittsburgh territory in so far as use by a water company was concerned and the consumers seemed, to a large extent, unable to understand it. We issued full explanations by letter to all our consumers, giving in de-

tail our reasons for increasing the rates and our reasons for changing to the new system. The feeling of many consumers, as indicated by their oral and written complaints or inquiries (whichever you wish to call them), seems to be that our charge per thousand gallons is what we are entitled to and the ready to serve charge is nothing but graft. Now do not misunderstand me that *most* of our consumers take this attitude. They do not, but when the company has 30,000 consumers to deal with and one is brought into contact with only those who complain, a few hundred seem like a great many.

Many of the consumers seemed unable to grasp the point that it took the meter charge plus the ready to serve charge to produce sufficient revenue to operate the plant and produce a reasonable return for the stockholders.

This ready to serve charge system is similar to the "demand charge" of many electric power companies, but domestic electric consumers, as a rule, do not get into the "demand charge" class so that did not help us much, nor for the same reason did the adoption a little later by the United States Post Office Department of their present system of ready to serve charges for parcel post service.

We have tried consistently, persistently and patiently to explain this system in a way that will make it clear to the ordinary domestic consumer, but have never yet been satisfied that the explanation made the matter clear to a majority of the inquirers.

I have also had at another plant considerable experience with a rate system under which the consumer "pays for what he uses"—with a small minimum. This schedule started at 22 cents per 100 cubic feet or about 30 cents per 1,000 gallons. The minimum was 1.25 per quarter so that it took only 700 cubic feet or 5,000 gallons to absorb the minimum. This rate was so low that I remember few, if any, complaints about it, either as to the rate or the method of calculating the bills.

This rate was increased 25 per cent on March 1, 1918, without opposition from the consumer and again increased September 1, 1924. As I see it, the principal difficulty with the "ready to serve" system is the lack of understanding on the part of the consumers. Of course many of them are foreigners who do not understand English to any extent, but even many of those who do seem unable to grasp the idea.

I noticed in the September 1, 1926, edition of the "Water Works Engineering," page 1121, an article by Caleb Mills Saville, the

Manager and Chief Engineer of the Board of Water Commissioners of Hartford, Connecticut, in which he speaks of "the odium of the hated service charge" and continues that Hartford adopted the minimum charge system "which is satisfactory to everybody." From this I take it that Hartford people do not favor the ready to serve rate system, although it seems to have the approval of divers commissions, rate experts and others who understand its principle.

As I have battled with these matters for a number of years I would like very much to hear what other members of the Association have found out about such matters.

METER OVER-REGISTRATION COMPLAINTS

F. B. BEECH:[4] Shakespeare must have had a disgruntled water consumer in mind when he wrote "More water glideth by the mill than wots the miller of" and having no water meter he did not have to concern himself with quantity. The water works man of to-day is well aware of the passage of this unheeded water and the task of imparting his knowledge to an incredulous and often times indignant customer, before a large and unsympathetic audience (waiting to pay bills), requires a great deal of tact as well as all the known virtues. In other words, he is sowing his seed on unbroken ground in a thunder storm. The ground is cultivated by some water companies by enclosing "water leak pamphlets" with all water bills and if these pamphlets were properly studied and understood, very few complaints would be received. The great trouble with pamphlets is that too many are received by the individual. He receives one with his gas bill, his electric light bill, his telephone bill and often with his milk, ice and bread bills. Personally I read none, excepting the water pamphlet, which is studied to pick out flaws. A full knowledge of the facts and personal contact, coupled with excellent judgment, are necessary to satisfy complainants. A useful means of demonstrating quantity is a coin with $\frac{1}{32}$-, $\frac{1}{16}$- and $\frac{1}{8}$-inch holes drilled though it and giving, under each opening, the gallons of water wasted in 24 hours at 40-pound pressure amounting to about 180, 960 and 3800 gallons, respectively. If it were not for the fact that 90 per cent of complaints are due to leaking toilets, it might be well to install three taps in a conspicuous place adjacent to where bills are paid, each tap placarded and running to waste at the aforementioned rate.

[4] Superintendent, Ohio Valley Water Company, McKees Rocks, Pa.

Usually sympathetic explanations are best, but occasionally the patient needs a major operation. For example, the Water Company received the following letter:

Gentlemen:

The enclosed 2 bills are extremely high. Could you not please investigate and reduce same? You can see for yourself that such large amounts are grossly exorbitant.

The reply was:

Dear Sir:

In reply to your complaint of exorbitant water bills, we find that each quarter you complain of high bills, but your complaint is not entered until bills are at least two months overdue and shut-off notice has been served upon you.

There is no mystery about the high bills and we have frequently pointed out the cause. The fault lies in poor piping and water fixtures, together with careless tenants, factors over which the Water Company has no control.

Instead of shutting off water to-day (as per our notice) we are extending the time until Wednesday, September 15th and trust we shall receive your remittance before that date.

The complaint having been made, the bill is lifted and marked "to be re-read." An inspector takes the bill, re-reads meter, entering date and reading on the bill, at the same time inspecting meter especially as to whether or not the register bands (straight reading meter) are shrunk by hot water or fire, also listening on water line for running water. The rate per day at which meter is running can then be determined up to time complained of and also from that time to the date of re-reading of meter. These facts are aids to arriving at a conclusion. If customer has a just complaint, a corrected bill is rendered. If the account is correct, the original bill is returned to customer with the notation in red. "Inspected and found correct."

We check for leaks by listening on water line and observing meter while all fixtures are closed and by making sure the toilet is not leaking at overflow, the discharge, or by reason of cracked overflow pipe. We also make certain that there is no intermittant leakage on account of flush ball not seating properly or by the float ball scraping against the side of tank.

As a final resort, consumer is referred to the following printed rule:

Should any consumer of the Water Company at any time doubt the correctness of the meter measuring his service, he may, on application to the Water

Company and the deposit of two dollars to defray the cost, have said meter tested, and should said test show the meter in question to be correct within 3 per cent he shall bear the cost of said test. On the other hand, should the test show the meter to be registering incorrectly beyond 3 per cent of the accurate amount, said deposit of two dollars shall be refunded and the account adjusted accordingly and the entire cost of the test shall be borne by the Water Company.

EXPERIENCES WITH LEADITE

CHARLES L. FOX:[5] Twenty years' experience with leadite has convinced the Pennsylvania Water Company that it is a very satisfactory jointing material and for that reason it is using no other material in the jointing of cast iron water pipe. When planning to use leadite for the first time, instruction should be sought in its handling, melting and pouring before attempting to make any joints with it. Otherwise the work will be a failure. A couple of hours of instruction from a competent instructor will prepare any person to make successful leadite joints.

The continued use of leadite will soon prove that it is an economical jointing material. It reduces the time required to lay pipe, saves in labor by eliminating large bell holes and the caulking of joints and reduces the waste of water by cutting down the leakage at joints.

Experiences gained recently while laying 6 miles of 20 inch pipe tend to show that joints made with leadite can be made nearly water tight with a little added care and attention. To obtain water tight joints the first suggestion would be to remove as much as possible of the protective coating from the outside of the spigot end and the inside of the bell of the pipe. It was observed while laying this 20-inch pipe during the winter that very excellent results were obtained in reducing leakage at joints. The pipe had been exposed to the cold and was full of frost so that before commencing to lay, it was necessary to heat the bell and spigot end of the pipe, which was done either with a plumber's blow torch or a bit of waste saturated with gasoline, then lighted and held to the part of the pipe it was necessary to heat. In doing this the protective coating was removed. After the pipe had been laid and the joints poured the line was tested in sections and it was surprising to find the uniformly tight joints that were produced under these conditions, as it had been anticipated that the number of leaking points due to the weather

[5] Assistant Superintendent, Pennsylvania Water Company, Wilkinsburg, Pa.

conditions and frost in the pipes would be greater than under the ideal conditions of summer.

Leadite joints have been found to leak more at the top where the

TABLE 1

Data of test of 25,462 feet of 20-inch cast iron bell and spigot pipe—1926

DATE	TIME	ELAPSED TIME		METER READING	DIFFERENCE BETWEEN READINGS*	DAILY DIFFERENCE 24 HOURS	GALLONS PER HOUR PER 100 FEET	GALLONS PER DAY PER MILE	GALLONS PER DAY PER INCH-MILE	GALLONS PER DAY (24 HOURS) PER FOOT OF JOINT
	a. m.	*hours*	*minutes*	*cubic feet*	*cubic feet*	*cubic feet*				
July 7	11:16	26	37	85,683	510	459.84	0.563	713.82	35.7	0.312
July 6	8:39	24	33	85,167	513	501.36	0.614	778.27	39.0	0.334
July 5	8:06	21	51	84,644	453	497.52	0.609	758.81	38.7	0.330
July 4	10:15	25	50	84,185	540	525.84	0.644	816.27	40.9	0.355
July 3	8:25	23	49	83,633	496	508.80	0.623	789.82	39.5	0.343
July 2	8:36	24	14	83,128	530	524.88	0.643	814.78	40.8	0.354
July 1	8:22	23	47	82,588	526	530.88	0.650	824.10	41.2	0.358
June 30	8:35	23	35	82,052	536	545.52	0.668	846.82	42.4	0.368
June 29	8:50	24	22	81,507	556	547.44	0.671	849.80	42.5	0.369
June 28	8:28	22	21	80,945	522	560.40	0.686	868.12	43.5	0.377
June 27	10:07	25	34	80,415	603	565.92	0.693	878.49	44.0	0.382
June 26	8:33	24	02	79,806	565	564.24	0.682	864.48	43.8	0.376
June 25	8:31	24	15	79,235	577	570.96	0.699	886.31	44.8	0.385
June 24	8:16	23	17	78,649	559	576.24	0.706	894.51	44.8	0.388
June 23	8:59	24	25	78,084	513	504.24	0.618	782.74	39.2	0.340
June 22	8:34	23	54	77,568	717	720.00	0.882	1,117.67	55.9	0.486
June 21	8:40	24	40	76,844	657	639.12	0.783	992.12	49.7	0.431
June 20	8:00	23	18	76,181	626	644.88	0.790	1,001.06	51.1	0.435
June 19	8:42	24	10	75,543	663	658.32	0.806	1,021.92	51.2	0.444
June 18	8:32	23	58	74,873	679	679.92	0.833	1,055.45	52.8	0.459
June 17	8:34	23	50	74,189	688	692.88	0.849	1,075.57	53.8	0.467
June 16	8:44	23	49	73,493	695	700.80	0.858	1,087.87	54.5	0.472
June 15	8:55	24	6	72,789	718	714.96	0.876	1,109.84	55.6	0.482
June 14	8:49	48	13	72,071	1,489	1,481.76	0.906	1,150.08	(57.6)	0.500
June 13	No reading taken								(57.6)	
June 12	8:36	23	42	70,582	751	760.56	0.932	1,180.63	59.1	0.513
June 11	8:54			69,831						

* Readings corrected by subtracting amount of water used through a service line on section tested.

pouring gate is attached than at the bottom or under side of the joint. The experience of last winter when the protective coating was removed would lead to the conclusion that the oil and tar of the coating floats to the top of the joint and mixes with the leadite, leaving it porous at this point.

Another lesson that was learned was that pipe laid and jointed during the hot summer weather should be tested and backfilled as soon as possible. Pipe that lies in the open trench for any length of time in summer seems to creep, due to the heating of the sun, with the result that the usual good adhesion of the leadite to the metal of the pipe is destroyed and numerous small leaks appear around the pipe, i.e., between the leadite and surface of the pipe. By testing and backfilling promptly the number of defective joints can be reduced and leakage reduced to a minimum.

Experience has shown that leakage through leadite joints tends to decrease with age. Tests of the 20-inch line recently laid show this to be a fact.

Table 1 shows the test of 25,462 lineal feet, or 4.82 miles of 20-inch pipe for a period of 26 days, June 11 to July 7, 1926, with the pressure ranging from 70 to a maximum of 225 pounds per square inch, depending upon the topography of the country through which the line was laid. It will be noticed that the daily difference in leakage dropped steadily from 760.65 cubic feet for the first 24 hours to 459.84 cubic feet for the last 24 hours of the test, or a decrease of about 39.5 per cent. The valves at both ends of the stretch of pipe to be tested were closed and water was supplied to the line at the upper end through a $\frac{5}{8}$ inch meter calibrated to register on a small flow of water. In this manner the pipe was always under a constant head of water and readings were made about the same time each day during the test.

MUNICIPAL FIRE HYDRANT RENTAL

W. C. Hawley:[6] A charge for public fire protection based upon an annual rate per hydrant is neither a measure of the cost of the service to the water utility nor of its value to the public. It usually results in the setting of a minimum number of hydrants with consequent poor quality of fire protection service so far as the public

[6] Chief Engineer and General Superintendent, Pennsylvania Water Company, Wilkinsburg, Pa.

is concerned and a return to the water utility of a revenue far below the cost of the service rendered. As a result, a considerable part of the cost of the service must be added to the domestic and industrial rates for water and thus the consumer who uses large quantities of water pays more than his fair share of the cost of fire protection service, while another consumer, whose property may be a serious fire hazard, will, because he uses a small amount of water, pay far less than his fair share.

In addition to an annual rate per mile of distribution system for public fire protection service, there should be a small annual rate per fire hydrant, sufficient to cover interest, depreciation taxes, and maintenance on the hydrant itself. This of course is small compared with the ordinary rate per fire hydrant, ranging from eight to twelve dollars. The result is that the municipality can order additional fire hydrants at a comparatively small increase in the annual bill for public fire protection. It has been the writer's experience that where the rates have been changed from the rate per hydrant method of charging to the rate per mile method, the number of fire hydrants has been increased by from 30 to more than 100 per cent. The results so far as the public is concerned are better fire protection and correspondingly lower fire insurance rates and a more equitable distribution of the cost of furnishing fire protection. The water utility generally receives an increase in revenue and is less liable to criticism for furnishing poor fire protection service. In this connection it should be kept in mind that but few of the Public Service Commissions have been willing to fix public fire protection rates which even approximate the actual cost of the service.

Another important feature of the rate per mile charge is that it assists in securing extensions of distribution pipe, where such extensions are necessary to reach prospective consumers. There has been some objection to charging for fire protection on a pipe on which a hydrant has not been set, but the water utility must make its investment in a pipe large enough to furnish fire protection when the pipe is laid and it is therefore reasonable that there should be revenue on this portion of the investment as well as on that required for domestic service. If this is not done, then either the rates paid by the domestic consumers must carry all of the investment in the extension or else the water utility suffers a loss until such time as the municipal authorities see fit to order a fire hydrant set. If there are domestic consumers, there must be buildings requiring fire protection,

and, since fire protection is a public matter, an investment to furnish such service should be paid for by the public.

COMPLAINTS—HOW HANDLED

D. C. GROBBEL[7] AND HAL SMITH:[8] The majority of municipally owned utilities realize that the good will of the public is a particularly valuable asset, and every effort is made to secure and hold that good will. No public utility, especially one owned by the municipality, enjoys hearing complaints on the service rendered and, though every effort is made to render efficient and adequate service, yet there is bound to arise a certain amount of dissatisfaction. Fortunate, however, is the utility that has the confidence of the public and is able thus to obtain from their dissatisfied customers a statement of their grievances, for, surely, no amicable adjustment can be made unless the utility has a knowledge that a grievance exists. For this reason, the Detroit Department of Water Supply has adopted the policy of encouraging the reporting of complaints, whether real or imaginary. It is then up to the complaint bureau of the Department to convert as many complainants as possible into satisfied customers, and it must be conceded that the bureau in this regard is functioning splendidly.

There are many different kinds of complaints received by the Detroit Department, but this paper is only concerned with customer accounting as related to the billing for water consumed. A study of the persons making complaints on the score of their water bills shows that these people may be divided into four distinct classes.

First, the person who honestly thinks he has been incorrectly billed. These cases are promptly investigated, and if bill is found to be in error, a corrected bill is rendered, with an apology for causing the customer any inconvenience. If correctly rendered, they are informed as to the cause of increased consumption with the advice that, if the cause has not already been removed, to do so at once, in order to reduce future bills. This service is appreciated, and as the customer is willing and expects to pay for all water consumed, it is seldom that any one in this class remains dissatisfied. The

[7] Assistant Superintendent (non-technical), Board of Water Commissioners, Detroit, Mich.

[8] Assistant Supervisor, Water Assessment Bureau, Board of Water Commissioners, Detroit, Mich.

Department finds that this class constitutes about fifty per cent of the total number of complaints.

Second, the excitable and thoughtless customer. He receives a bill somewhat higher than usual and without giving a thought to what might have caused it, rushes down to the office and demands an explanation. The Department is usually able to inform him at once of the cause of the increased consumption, by referring to reports made by meter readers. It is, however, not always an increased consumption, but often an additional charge made for meter repairs, or arrears added to current bill, both of which are plainly shown on bill, but which was not noticed by the customer. Usually the Department experiences but little difficulty in satisfying this class, as they have no desire to shirk a just bill. However, they are excitable and quick tempered, and it calls for a considerable amount of tact on the part of the complaint clerk to explain conditions without further arousing their anger. About thirty-five per cent of the complainants fall in this class.

A third class is that of the chronic kicker. This class complains simply for the sake of complaining and from force of habit. It is practically impossible to satisfy him, for the simple reason that he does not want to be satisfied. You cannot reason with him because he will not listen to reason. He simply states that the bill is wrong and won't pay it. He does not want an investigation made. He knows how much water he used and does not care what the meter reads. He says we are just as bad as the Gas Company, the Electric Company and the Telephone Company. He certainly should know because he makes the rounds regularly to all the utilities, always registering a complaint before paying a bill, whether the bill be large or small. If the bill is smaller than usual, he brings it in to show that he was over-charged on previous bills. The fact that the building was vacant most of the period means nothing to him. This is the class that tests the mettle of any complaint clerk. If the clerk cannot satisfy him, he must come as close to it as possible and get him out of the office before he becomes too noisy. Arguments of this kind have a bad effect on other customers who might also be in the office to question a bill, and it is quite possible that the argument might create another chronic complainer. The Department finds about ten per cent of the complaining customers come in this class.

The remaining five per cent is composed of those customers who

deliberately make an effort to get something for nothing. The person in this class receives a high bill and knows right well the reason for the increased consumption, but he is willing to make an affidavit that he knows there have been no leaks, wastage or increased consumption, and will invent an elaborate story to prove that the amount of water billed could not possibly have been consumed. He welcomes an investigation,—sure, certainly,—because he has already removed the cause of the high consumption. In this case, the complaint is given to one of the Department's investigators, who finds that the reading is correct, the meter in perfect order and showing no leak, and the consumption back to normal. However, a further investigation reveals a new toilet showing signs of being recently installed, or flush ball or washers replaced.

With this information at hand the complaint clerk is well armed, in fact, too well armed, for he has weapons that he cannot use. To prove that the complainant is a liar accomplishes nothing, it would simply cause the very thing that the Department is trying to avoid, namely, friction. So the tactful complaint clerk simply states that the reading was verified, the meter found to be in good order, and no leaks at present; that the increased consumption was apparently caused by a faulty toilet which had been recently repaired. He will probably think that the Department knows more about the facts than stated by the complaint clerk, but nevertheless it gives him a chance to save his face, and he quickly grasps the chance by blaming some tenant or employe for not informing him of the condition of the plumbing fixtures.

To properly handle complaints, as above classified, it is apparent that it is necessary to have a well trained and organized complaint bureau, whether it consist of one person or of a number of persons. In Detroit the complaint clerks are men who are familar with the construction, operation, and reading of meters, who have a fair knowledge of accounting and are especially equipped with an inexhaustible supply of tact, consideration and forbearance, ready at all times for instant use.

The complaint organization is a sub bureau, under the Assessment Bureau, which is that bureau of the Department which determines the amount of water to be charged against each consumer and such other duties as are naturally allied. Itemized, these duties are as follows:

Reading of meters.

Testing and reporting meters out of order.

Delivering bills.

Reporting new buildings ready for meter.

Reporting those that should be ready but are not. In brief, making a complete quarterly survey of the city to see that all water consumed is accounted for.

Estimating consumptions where no reading can be obtained.

Receiving and investigating complaints of water bills and performing such clerical work as necessary in carrying out the work of this Bureau.

It is therefore seen that the complaint bureau is working in close coöperation with that force that determines the amount of the water bills, and makes the reader's and investigator's reports readily accessible, and special information easily and quickly obtainable.

The Complaint Bureau proper consists of but two clerks; investigations are made by the two Meter Reader Foremen and a Chief Inspector. All correspondence is handled by the Supervisor of the Assessment Bureau or his Assistant.

The routine method of handling complaints is as follows:

Immediately upon receipt of complaint the account is checked for clerical error. If no mistake is found here, the meter reader's report is consulted to see if he has explained the high consumption. Usually he has, as one of the duties of a reader is to check any over or under consumption. With this information, the complaint clerk is able in most cases to convince the complainant that he is correctly billed. If he fails in this, he informs the customer that he will send out an investigator who will check the reading, examine the meter and if possible locate the cause of the increased consumption, and that he may obtain a report of the investigation by calling or phoning the office any time after the following day, or if he prefers he will be notified by phone or mail. A complaint form is then filled out giving such information as will be of help to the investigator.

The Department is not only willing, but is most anxious to spend any reasonable amount of time and money to secure the facts, in order that the consumer may be convinced that the Department has rendered a correct bill. It has been said that the large consumer, because of his superior maintenance organization, does not generally object to the bills of the Department, as rendered, but to illustrate the policy of the Detroit Department, an investigation of the water

consumption of the largest social club in the city of Detroit was undertaken. This club has been approximating a consumption valued at $1300.00 per quarter. For the quarter from January to May, the value of the consumption increased to $1800.00. Naturally, the manager of the club wanted to be shown; therefore immediate steps were taken to investigate the complaint. Meter reader reports were consulted and it was found that a Meter Reader had OK'd the reading. Further, that two days after the regular reading, a check reading was taken and found all right. The Department's Pitometer Engineer was sent on the job and spent several hours with a crew of men in the building, but could find no leaks. However, he found that the Club had indulged in a large number of swimming meets, both for men and women, during the quarter in question. Being of a sportive mind he discussed the swimming meets with the Maintenance Engineer and it was discovered that the pool had to be emptied three or four times for repairs and cleaning, and further that the swimming meets for the ladies took place in the afternoon and for the men at night and that the temperature of the pool for the men was 70 degrees Fahrenheit, and for the ladies, 80 degrees, necessitating a frequent partial emptying of the pool to attain the proper degree of temperature. A report was made to the club which apparently was not satisfactory. Again the pitometer crew made a survey and checked the meter against pitometer readings. In this check it was found that the meter, a six inch one, was registering approximately two per cent under the pitometer registration. On submiting this information, the manager of the club demanded a further check and again the pitometer crew made an inspection and survey of every water fixture and water line in the building. The result of this survey showed that there was considerable waste in the club's refrigerating plant. The findings of the pitometer survey were sent to the club manager and yet the club management was not satisfied. The survey and inspection cost the Department approximately $100.00. This is a case out of the ordinary, for usually the findings of the inspection made for waste or undue consumption are conclusive and there is no question on the part of the consumer, who usually follows the suggestion made by stopping the waste or repairing the leaking equipment.

Where, like the club mentioned above, the complaint bureau is unable to satisfy the complainant, the complainant may appeal to the Board of Water Commissioners. The Board of Water Com-

missioners, naturally, is unable to handle all the details of a department serving the public at the present time through over 220,000 meters, and the Board therefore has constituted an "Adjustment Committee," who sit as a Board of Review on the petition of the complainant and the findings of the complaint bureau. This Adjustment Committee is made up of the General Manager, Engineer of Water System, the Assistant Superintendent and the Superintendent of the Personnel Bureau. All the facts and findings in the case are submitted to this Committee in writing and the Committee makes the decision for or against the petitioner. The Committee further submit their decisions to the Board for approval.

This is final as far as the Department of Water Supply is concerned. Naturally the petitioner still can have recourse to the courts and to the Mayor and Council of the City, but since the institution of this Adjustment Committee as a final court of facts, no complaints against the bills of the Department have been carried to the Mayor, the Council or the Courts.

The Department has endeavored by all possible means to reduce the number of complaints and forestall many of them, first, by anticipation, that is, by notifying the consumer of an unusually high consumption immediately upon discovery by the reader, also informing him of the cause, where possible, and advising him to take immediate steps to remedy the trouble as it has already caused a considerable increase to his bill, and that a second high bill can be avoided by giving the matter his prompt attention. Second, a continual publicity campaign stressing the fact that water leaks or wastage are a real but unnecessary expense. Third, a firm policy of adjustments, making it clear to the consumer that it is useless to register a complaint where water is known to have passed through the meter, whether for useful consumption or through careless waste.

The Detroit Department considers its complaint bureau one of the most valuable adjuncts of the Department, and the writers in concluding the paper desire to credit the Supervisor of the Assessment Bureau for much of its success.

CARRYING CAPACITY OF PIPE

F. F. LONGLEY:[9] The writer would like to contribute to this discussion some records of hydraulic studies on reinforced concrete pipe lines built by the Lock Joint Pipe Company.

[9] Engineer, Lock Joint Pipe Co., Ampere, N. J.

TABLE 2

Values of "C" in lock joint pipe lines—Summary of results of recent observations on the hydraulics of several long sections of two lock joint reinforced concrete pipe lines

	TULSA, OKLAHOMA—SPAVINAW WATER SUPPLY LINE (NEW)			NORFOLK, VIRGINIA—LAKE PRINCE WATER SUPPLY LINE (3 YEARS OLD)	
	Section 1	Section 2	Section 3	Section 1	Section 2
Diameter of pipe, inches	60.0	60.0	54.0	36.0	36.0
Length of line under test, miles	6.6	15.3	4.0	2.17	2.47
Mean Velocity, feet per second	2.25	2.25	2.63	2.89	2.90
Rate of discharge, millions of gallons per day	28.596	28.550	27.029	13.20	13.23
Slope of hydraulic gradient, feet per 1000	0.2052	0.1880	0.2851	0.658	0.623
Value of "C" (Williams-Hazen)	145.4	152.4	152.1	138.0	142.0
Value of "C" (Scobey)	0.386	0.402	0.409	0.380	0.392

TABLE 3

Values of "C" in lock joint pipe lines: Summary of results of observations on hydraulics of 54-inch pipe line (Conduit No. 10)—Denver, Colo.

First section had been in service about 5 years; second section had just been put in service.

	TEST AT VELOCITY 3.50 FEET PER SECOND			TEST AT VELOCITY 2.58 FEET PER SECOND		
	First section	Second section	Combined	First section	Second section	Combined
Diameter of pipe, inches	54.0	54.0	54.0	54.0	54.0	54.0
Length of the line under test in miles	3.52	2.63	7.25	3.52	2.63	7.25
Mean velocity, feet per second	3.50	3.50	3.50	2.58	2.58	2.58
Rate of discharge, millions of gallons per day	35.96	35.96	35.96	26.46	26.46	26.46
Slope of hydraulic gradient, foot per 1000	0.5041	0.5330	0.5233	0.2673	0.3317	0.2994
Value of "C" (Williams-Hazen)	148.0	145.0	146.0	154.0	138.0	146.0
Value of "C" (Scobey)	0.407	0.396	0.400	0.412	0.370	0.390

Tulsa, Okla., has a water supply conduit built of lock joint reinforced concrete pipe 60 inches and 54 inches in diameter and with a total length of about 52 miles. Tests were made on the carrying capacity of this line shortly after it was put in service during the year 1924.

Norfolk, Va., has a 36 inch water supply line running in from Lake Prince. Part of this is of lock joint reinforced concrete pipe. Some studies for the determination of its carrying capacity were made in 1924.

The City of Denver, Colo., has several lock joint pipe lines among which is one 54 inches in diameter and nearly 10 miles long. About half of this line was built in 1920 and the other half completed and put in service in 1924. The carrying capacity of this line was determined by some carefully conducted studies early in 1925.

The Tulsa and Denver measurements were made by Fred C. Scobey of the Bureau of Public Roads, United States Department of Agriculture, whose pamphlet on "The flow of water in concrete pipe," (Bulletin 852, U. S. Department of Agriculture) summarizes a large volume of information on this subject. The Norfolk measurements were made by Walter Taylor, Commissioner of Public Works of Norfolk, collaborating with Dabney R. Maury.

The results of these studies have all been reported in some detail in the columns of the Engineering New Record within the past two years, and are given in summarized form in tables 2 and 3.

It will be observed at once that the values of "C" (Williams-Hazen) observed on these lines are remarkably high, the several figures ranging from a minimum of 138 to a maximum of 154.

The measurements on the Tulsa line and also on the second section of the Denver line were made when the pipe had been in service only a short time. The measurements on the Norfolk line were made when the line was about three years old, and on the first section of the Denver line when it was about five years old. An examination of the figures shows unmistakably that remarkably high coefficients were found in the pipe lines that had been in service three years and five years, without any evidence whatever of surface deterioration or falling off of carrying capacity as compared with the measurements made on new pipe.

REHABILITATION OF THE RACINE WATER WORKS[1]

By Donald H. Maxwell[2]

The water works at Racine, Wis., has been municipally owned since May 1, 1919. When taken over the plant was underbuilt, partly from the fact that several years of litigation preceding transfer had discouraged capital expenditures that could be deferred.

At the time of transfer, the investment in the plant, based on valuation at prewar prices, was equivalent to about $21 per capita. In contrast, the average per capita cost of water works plants in cities of over thirty thousand population was $32 per capita, as shown by the 1910 United States Census Statistics. This comparison confirms in a rough way the fact that the plant when purchased was considerably underbuilt.

PRINCIPAL DEFICIENCIES

The most important deficiencies were in intake and pumping capacity. It might also be added that the plant did not include filtration, although this development had been under consideration for a number of years during company ownership.

INTAKE CAPACITY

When the plant was taken over, the neck of the bottle was the intake. This consisted originally of a 24-inch cast-iron pipe extending 7600 feet to a submerged timber crib in about 40 feet of water and at the shore end turning down into a suction well.

The main pumps are set at about elevation +12, permitting them to develop a supply of approximately 5 million gallons per day. In 1899, the Company added a booster pump, which increased the intake yield to about 9 million gallons per day.

This booster installation consists of a screw pump mounted in a vertical shaft and supplied through a 4-foot tunnel by a siphon by-

[1] Presented before the Illinois Section meeting, March 24, 1926.

[2] Principal Assistant Engineer, Alvord, Burdick & Howson, Chicago, Ill.

pass connection from the intake line. This installation develops very nearly the maximum capacity of the intake.

By 1919 the screw pump had come into daily use, and the need of a reserve unit to boost to the suction well was urgent. This improvement was carried out in 1920.

NEW BOOSTER PUMP

The new booster installation consists of a slow-speed, direct-connected engine driven centrifugal pump, set at elevation −8, and taking suction from the tunnel through an 18-inch well casing driven through the brick roof of the tunnel. The pump also has a suction connection direct to the 24-inch intake line, permitting the tunnel to be by-passed for cleaning, and discharges through the intake to the suction well. This pump develops a slightly greater supply from the intake than it is possible to secure with the screw pump, and, in fact, develops the maximum capacity of the intake as a siphon, or a rate of about 9.5 million gallons per day.

This booster equipment enables the plant to supply a city of 70,000 through a long 24-inch intake, and in connection with storage now provided or under construction, is expected to make the present intake sufficient for the city's requirements for several years to come.

GENERAL REPORT

While this improvement was under way, at the request of the Water Board a general report was made in 1920, outlining a comprehensive program of betterments.

NEW SITE

Study of the water works lot in connection with the required improvements made it evident that a better site was urgently needed. The existing lot is from 100 to 125 feet wide by about 900 feet long, but badly divided by railroad switch tracks serving adjoining manufacturing property under conditions making it out of the question to eliminate them. These facts led the Board to secure the best available new site, a tract 260 feet wide by 1000 feet long and located two blocks north of the old plant. This lot is well situated and provides sufficient space for future expansion, so far as future requirements can be foreseen at this time.

COAGULATING BASIN

After careful study of the new site, a general design of the future plant was made and a program laid down for its construction in installments from time to time out of plant earnings, giving preference to the more urgent improvements. This program contemplated building the new intake first, but shortage of funds and the prevailing high price of cast iron pipe led finally to a decision to build instead the coagulation basin of the proposed filter plant, the idea being that this would provide sufficient storage, using it as a reservoir, to tide the city over the intake deficiency for a few years and have the advantage over a new intake at that time of considerably less expenditure and some improvement in the water supply, through sedimentation. The coagulating basin was purposely built somewhat large to provide adequate reserve water supply, and has a total sedimentation period of about six and one-half hours based on the present average daily pumpage.

The basin was completed in 1925 and provided with temporary connections to permit its use as a reservoir. It is connected with the old site by two mains, one for supply and one for outlet, one of which may in the future be utilized as a high pressure discharge main from the new station, and the other as an extension of the old intake to the new station suction well.

FILTER PLANT

In the meantime, local conditions developed which led the Board again to postpone the proposed new intake, in favor of completion immediately of the filter plant. This plant is now under construction and is to have a rated capacity of 12 million gallons and total filtered water storage of 3 million gallons. This increased storage will make the existing 24-inch intake sufficient for a few years more, or until such time as the Water Department can accumulate a sufficient construction fund to finance the proposed new intake out of earnings, in accordance with the policy adopted by the Board.

FUTURE IMPROVEMENTS

After the proposed intake and new suction well have been provided at the new site, the next step will be to build a complete new pumping station adjoining the filter plant. The new plant is laid

out to lend itself to orderly expansion from time to time to meet the future needs of the city and probably even its ultimate requirements, so far as they can reasonably be anticipated at this time.

MANAGEMENT

The Racine Water Department is controlled by a Board of Water Commissioners, and is under the direct management of F. M. McElroy, who was also Superintendent of the plant under private ownership.

PROGRESS REPORT OF COMMITTEE ON STANDARD FORM OF CONTRACT[1]

The Committee on Standard Form of Contract has been inactive during the past year. This policy was followed in order to learn by experience how the public received the standard contract forms which the Committee helped to prepare as an affiliate in the Joint Conference on Standard Construction Contracts. These forms will be found on pages 715–727 of the "Manual of American Water Works Practice."

The documents relating to engineering contracts are printed officially for the Joint Conference by the Associated General Contractors of America. They are on 9- by 12-inch sheets readily bound with the typewritten specifications, notice to bidders and other documents making up a complete set of contract papers. About a thousand of these documents have been sent out as a result of requests received at the office of the Associated General Contractors in the Munsey Building, Washington. The standard engineering construction documents have also been published unofficially in the Proceedings of the American Society of Civil Engineers as well as in our own Manual, and probably some use has been made of them by copying from these sources. They have not yet been out long enough to enable one to judge what their future usefulness will be.

Your Committee is desirous of learning the experience of our members in using, or attempting to use, these documents, which represent a great deal of labor and study by engineers representing all branches of the civil engineering profession, delegates of the American Institute of Architects, general contractors, and lawyers specializing in contract law.

The American Society of Municipal Improvements has been considering for some time this subject of standard construction contracts, and one of its committees will present at the annual meeting in the coming Autumn a set of documents much like those of the Joint

[1] Presented before the Buffalo Convention, June 8, 1926.

Conference, except that references to arbitration are omitted as mentioned in the footnote on page 715 of our Manual.

Your Committee asks the Association to receive this report and to continue the Committee.

Respectfully submitted,

J. WALDO SMITH, *Chairman,*
Committee on Standard Form of Contract.

REPORT OF COMMITTEE NO. 1 ON STANDARD METHODS OF WATER ANALYSIS[1]

Your Committee No. 1, on Standard Methods of Water Analysis, begs leave to submit the following report for the year 1925–1926:

This year has seen the appearance of the Sixth Edition of the Standard Methods for the Examination of Water and Sewage prepared jointly by the Committees of the American Public Health Association and the American Water Works Association. This represents the first edition under the coöperative arrangement. The material for this edition was submitted and approved at the Convention in Louisville in 1925.

The work of your Committee No. 1 during the current year has consisted almost entirely of research work as detailed herewith.

The Composition of Billiant Green Lactose Peptone Bile, H. G. Dunham, Referee

Mr. Dunham and Dr. Levine, with the assistance of Dr. John F. Norton and Dr. S. A. Koser, are working on a comprehensive program to improve the brilliant green lactose bile medium. The points which are being given careful, scientific consideration are:

The concentration of the bile
The concentration of the brilliant green
The hydrogen ion concentration of the completed medium

Work has been carried out at Iowa State College at Ames, under Dr. Levine, at the plant of the Digestive Ferments Company, at Detroit, under Mr. Dunham, at the University of Chicago, under Dr. Norton, and at the University of Illinois, under Dr. Koser. The technical details of Dr. Levine's results so far are included later, under Dr. Levine's name, as they were submitted by him. The assistance

[1] Presented before the Buffalo Convention, June 11, 1926. Committee No. 1 consists of Jack J. Hinman, Jr., Chairman, R. C. Bardwell, John R. Baylis, L. I. Birdsall, Julius W. Bugbee, A. M. Buswell, H. G. Dunham, Norman J. Howard, Harry E. Jordan, Wilfred F. Langlier, Max Levine, MacHarvey McCrady, Dale L. Maffitt, F. W. Mohlman and E. C. Trax.

of the Digestive Ferments Company in the study of this medium is particularly appreciated, as they have contributed materially in a financial way to the support of the work.

The work carried on by Dr. Norton includes the use of two strains of Bact. coli giving the typical reactions of fecal Bact. coli. His results, representing averages of seven series of counts with each organism, indicate that lactose peptone bile containing one, two or five per cent bile causes a slight inhibition of these strains as compared with peptone water. In the 2 per cent bile medium containing added brilliant green an appreciable inhibition was noted with both cultures in the 1:5000, 1:7500, 1:10,000 and 1:12,500 concentration of brilliant green. A lesser inhibition was noted in the 1:10,000 brilliant green 2 per cent bile medium with both cultures. Additional work is being planned using freshly isolated cultures.

The work of Dr. S. A. Koser has been to determine whether or not aerobic spore formers will grow in lactose peptone bile or brilliant green bile. Up to the present time, he has used 20 cultures of aerobic spore-forming lactose fermenters in 12 different media. One series of six included five different concentrations of brilliant green from 1:15,000 to 1:100,000 in 2 per cent lactose peptone bile with a control containing no brilliant green. The other series included five different concentrations of brilliant green from 1:10,000 to 1:30,000, in 5 per cent lactose peptone bile with a control containing no brilliant green. His tests were further controlled with standard lactose broth. The method was to inoculate each medium directly from young agar slants and incubate at 37°C.

Two types of cultures were used. Type I is apparently quite common in soil around Urbana and appears to be about the same as the cultures described by Hinman and Levine in Iowa, and by Norton in Chicago. Type II was rarely found in the Urbana locality.

All of the 15 cultures of Type I tested so far were inhibited by all bile media and brilliant green bile media (no visible growth and no gas production even after seven days at 37°C.). Apparently the inhibition is due to the bile since the control tubes of bile alone, both 2 and 5 per cent gave the same result. Standard lactose broth served as a further control. In this medium (standard lactose broth) the amount of gas produced by spore-formers varied from a bubble to 30 per cent; after forty-eight hours it was more pronounced and varied between 10 and 50 per cent.

Using five cultures of Type II, growth and gas production was apparent in all 12 bile and brilliant green bile media, sometimes only a bubble of gas after twenty-four hours, but usually pronounced after forty-eight hours. Very little, if any, inhibition was noted in comparison with the standard lactose broth.

Further work is planned using diluted water suspensions of the Type II cultures as an inoculum for the bile media. Plate counts on this type to compare their growth on bile media as compared with standard lactose broth are also planned.

The work in the laboratories at Detroit which was performed by Mr. H. W. Schoenlein has likewise been quite extensive. The growth of Bact. coli (fecal) was determined in lactose peptone bile media containing 1, 2, 3, 4 and 5 per cent bile. A control medium composed of the lactose peptone fraction of the bile medium was carried along. Tubes, in a 37°C. water bath, were inoculated with a measured amount of an active broth culture of two or more organisms. A mixture of cultures was used to minimize the effect of the individual. The test cultures were plated out on 1.5 per cent nutrient agar after five or six hours incubation at 37°C. in the water bath.

As a result of seven series of platings, using a mixture of two stock laboratory strains of fecal coli in 3 series, and a mixture of three fecal coli's isolated from rabbit, dog, and human feces respectively in four series, and employing two different oxgalls in the above mentioned media, the following conclusion is made: "In every case a decided stimulation was apparent in the bile media as compared with the control medium, which was the same as the bile medium except that no bile was present. It was also apparent from this series that from 1 to 3 per cent bile was the optimum concentration."

Further work is under way in studying the effect of the brilliant green and the effect of the hydrogen-ion concentration.

Conclusions. Until more cultures are used and reported by Dr. Norton, no conclusions can be drawn from his work. Plain lactose peptone bile and brilliant green bile media inhibit the growth of the more common lactose fermenting aerobic spore formers when inoculated in smaller quantities. The work here indicates that, as far as the cultures of fecal coli used are concerned, both laboratory stock and freshly isolated strains are stimulated by the presence of from 1 to 3 per cent bile in lactose peptone bile.

Non-Confirming Spore Formers and Their Significance in Water Examinations, Norman J. Howard, Referee

During the past year chief work has centered upon securing additional information on the subject, in correlating the ideas of observers on their local conditions and in securing and studying the characteristics of cultures. Correspondence with numerous observers has shown wide differences of opinion. In some cases such opinions are purely hypothetical and have no sound basis. It has been difficult to secure cultures. Of the cultures submitted some were contaminated, some were anaerobes and some only fermented lactose under difficult conditions of cultivation. Work is being continued. A brief résumé of observations recorded is as follows:

1. It is possible that troubles experienced in certain districts are not directly attributable to the presence of spore formers, but are caused by the combined presence of two distinct types of organisms neither of which are spore formers, but which produce gas in symbiosis.

2. In some districts the difficulty in confirming presumptive tubes is undoubtedly caused by spore formers.

3. Some specimens fermented brilliant green bile broth and lactose broth in twenty-four hours.

4. The use of dyes and bile broth cannot be depended upon to eliminate even their primary growth.

5. In some instances the use of bile in small quantities prevented the growth of spore formers.

6. There is no evidence, based upon cultures submitted, that the majority of non-confirming spore formers found in treated waters are B. welchii. They undoubtedly belong to a large group of unclassified spore forming bacteria.

7. The significance of the non-confirming spore forming bacteria in treated waters has not been demonstrated. Generally speaking, provided the colon group have been destroyed by purification processes, the spore forming group are unimportant.

8. In judging the quality of untreated water their presence may be of value in determining the probable source of pollution.

9. The pathogenicity of numerous strains is being determined and will be reported upon at a later date.

10. The presence of spore forming organisms in water has given in the past and doubtless will in the future give rise to grave inaccuracies unless steps are taken to provide a medium which will eliminate their growth in the primary test.

11. Work is being carried out along these lines, but on account of other studies overlapping, it is probable that much work is being unconsciously duplicated.

It is suggested that this study should not be confined to the spore forming group, but to include all non-confirming lactose fermenting organisms found in water.

Appreciation is expressed to Messrs. J. S. Gettrust, J. C. Weldon, Frank Raab, J. K. Hoskins, G. E. Willcomb, W. S. Mahlie, and R. E. Thompson for assistance to the referee in this study.

Use of Brilliant Green Bile and Media Containing Other Tri-Phenyl Methane Dyes as Secondary Fermentation Media in the Determination of the Bacteria Coli Group, Harry E. Jordan, Referee

Details of this work will be found described in part in the December, 1925, issue of THE JOURNAL. Additional summaries will be submitted at a later date.

The Use of Eosine Methylene Blue Agar and Modifications in the Confirmation of Organisms of the Colon Group, Max Levine, Referee

The work on the assigned subject is being deferred while Dr. Levine coöperates with Mr. Dunham, Dr. Norton, and Dr. Koser, on the composition of brilliant green bile. The status of the work on brilliant green bile as carried out in coöperation with Mr. Dunham, Dr. Norton, and Dr. Koser, is as follows:

The plan of the work was first to ascertain the optimum concentration of bile for stimulation of growth of Bact. coli, and then to ascertain the optimum concentration of brilliant green when employed with the previously determined optimum bile concentration.

Employing bile alone (that is, without brilliant green) a concentration of 2 per cent was practically always the best, in that there was always stimulation, although the degree of stimulation of growth varied with the different batches of bile employed.

With 5 per cent bile, the results were much more variable, one batch showing distinct inhibition, while another showed distinct

stimulation in the growth of a mixture of strains of Bact. coli. It was felt that the differences observed might be explained in part at least by the differences in reaction.

Mr. Dunham prepared three batches of 5 per cent bile media with reaction of pH 6.0, 7.3 and 7.8. The generation times for a mixture of 5 strains of Bact. coli in these bile media were 30.9, 26.2 and 25.8 minutes as compared with 30.0, 30.1 and 35.0 for lactose broth media of corresponding reactions. It will be observed that in the alkaline reaction (pH 7.8) the 5 per cent bile was distinctly stimulating whereas in the acid reaction pH 6.0 it was slightly inhibitory.

It is, therefore, evident that in all future work on this project, it will be necessary to control the H-ion concentration in order to have comparable results.

The optimum concentration of brilliant green is a function of the concentration of bile. In 2 per cent bile, best results were obtained with 1:100,000 brilliant green and with 5 per cent bile 1:25,000 to 1:30,000 brilliant green appeared best. In general 1:30,000 brilliant green had about the same stimulating effects on growth of Bact. coli. Higher concentrations of the dye exerted a slight to distinct inhibition.

The experimental work upon which this report is based was done by Mr. H. W. Coles as a thesis for his master's degree in bacteriology.

The Use of Brilliant Green Bile as a Primary Medium in the Detection of Organisms of the Colon Group, MacHarvey McCrady, Referee

Work on the above assignment was confined, during the past year, to preparation of a report, for publication in THE JOURNAL, on the results obtained during the intensive study of the two preceding years. In collaboration with Mr. H. G. Dunham and Mr. H. E. Jordan, who were interested in particular phases of the general subject, a report was prepared and published in THE JOURNAL, December, 1925.

Considerable interest appears to have been aroused by this work of the past three years, as several requests for information regarding details of the work and several offers of contributions to the study have been received from laboratories not represented in the Association.

During the past year further study was given the medium by Mr. C. J. Lauter of the Washington Filtration Plant. A preliminary comparison of results obtained with the medium and with standard broth was forwarded by Dr. A. H. Straus of the Bacteriological Laboratories of the Virginia State Board of Health, which indicated that the brilliant green bile medium might clear up certain anomalous results yielded by the standard broth when employed on some open swimming pool waters. Dr. Straus is carrying this work further.

To satisfy the demand of those laboratories which have found the medium of particular value in their work, a dehydrated brilliant green lactose peptone bile medium has been prepared by Mr. Dunham, which has been tested and approved by Dr. F. E. Hale (in whose laboratories the original medium was prepared), and has been placed on the market by the Digestive Ferments Company of Detroit Mich.

The first phase of the work on the above assignment is now considered concluded. A large mass of data has been gathered on the value of this medium, and it is believed that the data are of particular interest in that they are based upon a medium made up of standard ingredients; each ingredient was given special consideration, and, where necessary, the specified ingredient was furnished the various associates, so that all might work with the same materials. It is believed that a few individual reports, however complete, could never have permitted the satisfactory judgment of the value of this medium obtained from consideration of this mass of data obtained from all sections of the country and from a great variety of waters.

These data have indicated very clearly that in some localities and with some waters the medium will give excellent results, but that it is not of general utility, as some waters have not yielded satisfactory results with the medium.

The next phase of this investigation must include a study of the possibility of improving this medium, which so nearly answers the requirements of a rapid, trustworthy presumptive medium, and the development of this phase is now in the hands of members of the Committee, as has been above indicated.

The Microscopic Examination of Water, W. F. Langlier, Referee

A Foerst continuous centrifuge, operating at 15,000 r.p.m. is now available to the Referee, and he is conducting tests on it in com-

parison with the net and the Sedgwick-Rafter methods, for the enumeration and estimation of the plankton organisms. A few trial comparisons have been made using all three methods. The work is slow and tedious and it is not always possible to secure suitable specimens of water. It is believed that the Foerst centrifuge marks a considerable advance over the older methods, but that it requires careful comparison with the older processes. It is hoped to have enough data accumulated by fall to permit certain conclusions.

The Mineral Analysis of Water, R. C. Bardwell, Referee

The progress in connection with mineral analysis of water for boiler purposes pertains largely to a thorough test of the recommended procedure published in THE JOURNAL, August, 1925, of the Association.

These methods have been given special consideration and tests in a large number of railway water laboratories with very satisfactory results. It is the recommendation of the Referee that the published procedure be adopted for standard practice in the examination of waters for railway boiler purposes and small steam supplies.

Mr. Bardwell, the referee, is also a member of Committee No. 19, under the chairmanship of Mr. S. T. Powell. The purpose of this arrangement is to insure the coöperation of both committees and to permit free interchange of available information.

The Determination of Turbidity and Coefficient of Settling, John R. Baylis, Referee

Work on a method for making accurate turbidity measurements of filtered water has been completed. A new turbidimeter has been designed. The new instrument is essentially the same as the one described in THE JOURNAL, July, 1924, page 824, but is of much neater design. Plans of the new turbidimeter and a method of procedure for making turbidity measurements with the instrument were published in Industrial and Engineering Chemistry, March, 1926, page 311.

There is yet the problem of trying to find a suitable method of procedure for measuring the floc turbidity, that is, coagulated matter passing a rapid sand filter bed. There is also need for a simple and reliable instrument to make turbidity measurements between

2 and 25. Some consideration will be given to this during the next year.

The Determination of Dissolved Oxygen, J. W. Bugbee, Referee

The original Winkler method is prescribed for use with waters containing less than 0.1 part per million of nitrite nitrogen, while the Rideal-Stewart modification is made the standard method for all waters containing more than 0.1 part nitrite nitrogen.

In paragraph 5 (Calculation of Results) mention is made of the fact that values in excess of 100 per cent saturation sometimes occur, and this condition is attributed to the presence of oxygen-forming plants. From the writer's own experience, and from reports received from other workers, it appears that this condition of supersaturation sometimes occurs under such circumstances that it cannot be explained by the reason given above. If other causes could be definitely proven, they, also, should be stated in paragraph 5 and the writer would suggest that committee members or other laboratory workers who may have met with such conditions be asked to report the facts in detail, with their theories or opinions as to the cause.

The fact that the modified Winkler method gives erroneous results, in the presence of iron salts, was brought out by Buswell and Gallaher, and, as they found that the error could not be corrected by applying a factor based on the amount of iron present, they advocated the use in such cases of the Levy method as modified by Letts and Blake. If this suggestion were to be followed, however, it would necessitate publishing the modified Levy method as an alternate to the Winkler method.

In Public Health Bulletin No. 151 (The Determination of Dissolved Oxygen by the Winkler Method) it is suggested by the author, E. J. Theriault, that the oxidizing effect of ferric chloride could be inhibited by the addition of sodium fluoride, and he proposed this as a modification of the Winkler method for liquors containing iron. Unfortunately, he did not use in his experiments as large amounts of iron as are sometimes found in actual field tests, and until further work is done along this line, the advisability of including his suggested modification is still somewhat in doubt. Undoubtedly the interference of iron should be mentioned in Standard Methods, and a method should be indicated for overcoming this interference, as soon as such method can be standardized. Until such time, it

would appear that it would be of great assistance to a student of the problem to insert in the biliography of Section xxiv, the titles of the two articles mentioned above:

Buswell, A. M., and Gallaher, W. V. Determination of Dissolved Oxygen in the Presence of Iron Salts. Industrial and Engineering Chemistry, Vol. 15, No. 11, p. 1186 (1923).

Theriault, Emery J. The Determination of Dissolved Oxygen by the Winkler Method. Public Health Bulletin, No. 151 (1925).

The Determination of Free Chlorine, A. M. Buswell, Referee

The Referee and Professor Boruff, of Monmouth College, have concened themselves with the sensitivity of the ortho-tolidine method as compared with the starch iodide method for the determination of free chlorine. Both tests seem to be equally sensitive, giving a positive test for 0.005 part per million of excess chlorine in a 50 cc. Nessler tube at room temperature. The ortho-tolidine method is affected by iron when present as the chloride or nitrite above one part per million. Nitrites in low concentrations do not affect the test. Above one part per million they are objectionable. The hydrogen ion concentration is an important factor. The most sensitive concentration is that given by 2 cc. of concentrated hydrochloric acid in 50 cc. of water. The starch iodide test is more satisfactory for very low temperature determinations, but in general the ortho-tolidine test is preferred. The latter is much simpler than the other test in practice, since but one solution is required in addition to the standards.

At the request of the Chairman of the Committee, Dr. Buswell and Dr. Boruff have conducted an investigation into the preparation of ortho-tolidine solutions, requests having been received for information concerning residues remaining after attempts to dissolve the ortho-tolidine according to the method given in the Sixth Edition of Standard Methods. The conclusion reached is that ortho-tolidine is soluble in dilute hydrochloric acid but not in concentrated hydrochloric acid. This is undoubtedly due to the formation of ortho-tolidine hydrochloride, which, in turn, is soluble in water. It was noted that the impurities found in some commercial ortho-tolidine were not soluble in dilute hydrochloric acid but soluble in concentrated hydrochloric acid. Hence the action of dilute hydrochloric on the impure ortho-tolidine apparently dissolves very little of the impurities which may be filtered off. If concentrated

hydrochloric acid instead of dilute hydrochloric acid is used in the preparation of the solution, which is then diluted to the desired strength, the dark colored impurity goes into solution and the ortho-tolidine is thrown out of solution. This is the reverse of what is desired.

The above situation results in one author reporting a residue soluble in water and insoluble in concentrated hydrochloric acid, while another author reports a residue insoluble in water but soluble in concentrated hydrochloric acid. The fact is they are dealing with different residues. The residue which is soluble in water is the ortho-tolidine or otho-tolidine hydrochloride, while the other residue, which is soluble in concentrated hydrochloric acid, is the impurity found in the material. The dark colored impurity is undesirable because when put into solution a colored liquid results which interfers later in the determination of free chlorine according to this method.

The Determination of Free Carbon Dioxide in Water, Dale L. Maffitt, Referee

In the search for a new method for the determination of free carbon dioxide in water an endeavor has been made to survey the available literature on the subject; actually to try experimentally in the laboratory some of the methods suggested; as well as to determine the practicability of new ideas which were conceived from time to time.

It has been found that a considerable amount of work has been done on the determination of carbon dioxide along three lines, namely: (1) Titration (2) Absorption (3) Volumetric Methods.

A method suggested by Dietl has been investigated. In this method the sample of water is added to an excess of standard sodium hydroxide solution. To increase the sodium ion concentration, so that the carbon dioxide will stay in solution, a reagent such as sodium citrate or tartrate is added, after which the mixture is titrated back with standard acid to find the amount of excess of sodium hydroxide. It was found that in this method practically all the difficulties found in other titration methods were encountered. Especially is this true where the water to be tested contains any salts that give an acid reaction in solution, such as iron and aluminum compounds and so forth. Also with the excess amount of

sodium ions present the phenolphthalein indicator does not give a sharp end point.

J. Johnston points out that one of the disadvantages of such a method as described above is that varying amounts of carbonates, bicarbonates and carbon dioxide require different amounts of indicator to produce accurate results. Johnson also states that the only absolutely reliable methods are those determining the total base combined with carbonic acid and the total carbon dioxide present in solution and then subtracting to get accurate amount of free carbon dioxide.

The ordinary potash bulb absorption and also volumetric methods as suggested by Treadwell and Swanson and Hulett and others are not feasible for standard methods use, due to the outlay for complicated apparatus and the elaborate technique in handling same. These methods, however, are more accurate than the titration methods.

In a method lately suggested by E. M. Crowther and W. S. Martin, the sample is added to standard calcium hydroxide together with calcium chloride to precipitate the carbon dioxide as calcium carbonate, after which the mixture is titrated back with normal acid. This being a titration method would no doubt suffer from many of the disadvantages of the other titration methods. It too is but a variation of the barium hydroxide method given by Treadwell and Hall.

Thymol blue indicator was tried, but it does not seem to have an advantage over phenolphthalein, because it does not have a sharp end point under the experimental conditions.

An endeavor was made to adopt a method somewhat similar to that suggested by Swanson and Hulett. The scheme was to use mercury in a Muencke-Orsat apparatus, which was connected to the vessel containing the sample of water. The pressure over the sample was reduced by allowing the mercury to flow from measuring tube into the aspirator bottle. The carbon dioxide thus drawn from the sample was passed into the potassium hydroxide pipette of the apparatus and the amount of carbon dioxide noted by the reduction of pressure indicated on a manometer connected with the system. It was found, however, that the technique required was too elaborate for ordinary procedures and that it would therefore not be practical for inclusion in the standard methods.

The conclusions on the work thus far are as follows:

The present method as outlined in Standard Methods is the most practical for ordinary procedure, even though it is somewhat inaccurate. Where extremely accurate results are necessary as with some particular types of water the present method may be augmented by some more highly technical method such as the absorption method, thereby obtaining a factor of error to use in that case with the present procedure.

Some of the methods suggested have a slight advantage for particular waters, but it appears that absolutely accurate results can only be secured by comparatively complicated methods, and no method thus far suggested has especial advantage over the present method as outlined.

The Determination of Biochemical Oxygen Demand, F. W. Molhman, Referee

Various investigations have been made during the past year concerning the technique and interpretation of the biochemical oxygen demand determination. The most extensive work has been done by E. J. Theriault in the laboratory of The United States Health Service at Cincinnati, by R. E. Greenfield and A. L. Elder at the Illinois State Water Survey, and by various investigators in the laboratories of the Sanitary District of Chicago. Results of work done in the first two laboratories have been published under the following titles: "The Rate of Deoxygenation of Polluted Waters," Emory J. Theriault (Proc. Amer. Soc. Civ. Eng., 51, 9, 1819–28, November, 1925); "Effect of Temperature on Rate of Deoxidation of Diluted Sewage," R. E. Greenfield and A. L. Elder (Jour. Ind. and Eng. Chem., 18, 3, 291–2, March, 1926).

Very important facts have been brought out in both investigations concerning oxygen demands over long periods of incubation, up to 180 days. Results have shown that the demand for oxygen is far from being satisfied in twenty days at 20°C., but that absorption takes place in two stages, the first extending over ten days at 20°C., the second over a period of months. In explanation of the secondary phase, Theriault believes that it is the stage of nitrification, while the first phase is the stage of carbon oxidation; Greenfield and Elder believe the secondary phase is primarily the demand of dead organisms. The latter investigators claim the second stage was not obtained with sewage, but only with river water, while Theriault

claims to have had similar results both with sewage and river water. This divergence of opinion must be reconciled by further work.

The rates of satisfaction at various temperatures have been determined, and are reported in both papers.

In the laboratories of the Sanitary District of Chicago comparative studies are being made (1) of the nitrate and dilution methods, (2) of the rates of satisfaction for raw sewage, effluents and river water, and (3) of the use of various types of diluting water. The present indications are that: (1) Results by the nitrate method are from 10 to 20 per cent lower than by the dilution method (5 or 10 days at 20°C.). (2) With fresh sewage or recently polluted water the rate of satisfaction of demand follows a logarithmic curve, but with nitrified effluents and river waters that have undergone considerable self-purification the rate of satisfaction is approximately uniform or straight-line. (3) Various types of dilution waters give variable results. Distilled water has given lowest demands, surface water highest, deep well and buffered distilled waters intermediate demands. Distilled water buffered with 500 mg. per liter sodium bicarbonate has been quite satisfactory. It has the advantage that it can be duplicated in different laboratories.

No results are now available concerning similar investigations in other laboratories. The referee would appreciate information regarding any work that has been done on this determination.

The Determination of Small Quantities of Phenols in Water Supply, E. C. Trax, Referee

Mr. Trax has been prevented from carrying out the work outlined on account of the pressure of personal business. He has, however, made a survey of the situation in the Pittsburg region and finds that taste and smell are largely depended upon in that vicinity to detect traces of phenols. The Folin and Denis reagent has been employed to some extent, but is not considered to be sufficiently accurate for the purpose.

The Field Representative, L. I. Birdsall

Mr. Birdsall has been able to put the Chairman of the Committee in touch with a number of water works men who were interested in different phases of work being investigated by the different Referees of Committee No. 1. The Referees concerned have been notified

of the interest of the individuals mentioned, and it has been possible to secure coöperation from several of these.

RECOMMENDATIONS

Your Committee would recommend that the work at present being undertaken be continued, and that it be given authority to extend its operation to such additional subjects as may be advisable during the year, subject to the approval of the Standardization Council. It is recommended that the Committee shall coöperate in every way with the Committees on the Study of Boiler Waters, headed by Mr. S. T. Powell and Mr. Harold Farmer.

It is not considered that the work on any of the items in this list of subjects is sufficiently complete to be considered finished. Committee No. 1 would therefore suggest that the Committee be continued during the coming year.

Merritt Haviland Smith

Died December 9, 1926

Merritt Haviland Smith was born in New York City, on May 21, 1862. He was the son of Merritt Haviland and Mary Adelia (Howard) Smith. He graduated from Pennsylvania Military College with the degree of Civil Engineer in 1880. From 1880 to 1881 he studied law, and from 1881 to 1884 he was Engineer with the Pittsburgh and Western Railroad.

In 1884 he entered the service of the City of New York, in the Department of Public Works, and was engaged as Engineer on the work of the Croton aqueduct until 1890. In 1890 and 1891 he was engaged on general engineering work in connection with the development of lands in Florida, but in 1892 he returned to the service of the City in the Department of Finance, in which Department he continued until 1906. During this period he was also, from 1900 to 1902, Park Commissioner for the City of Yonkers and Police Commissioner for that City during 1905 and 1906.

In 1906, with the beginning of the work on the City's new water supply from the Catskill Mountains, he was appointed Department Engineer to the Board of Water Supply and placed in charge of the Southern Aqueduct Department, which covered all of that portion of the Catskill work from the Hudson River crossing south to the City line, including also Kensico and Hill View reservoirs. In 1910 he became Deputy Chief Engineer of the Board of Water Supply, and in 1914 was appointed Chief Engineer of the Bureau of Water Supply of the Department of Water Supply, Gas and Electricity, which Department has charge of the construction, maintenance and operation of the water supply systems of the five boroughs of the City.

On June 30, 1917, he was called into Federal Service, with the 104th Field Artillery, of which he was Colonel. On February 12, 1919, he was discharged from Federal Service, and returned to duty in the Department of Water Supply on February 13, 1919.

His long experience in military service began when he became a member of 7th Regiment, N. G. N. Y. in 1880. He served with Squadron A from 1896 to 1907, and for about six months of this period was Captain and Major, respectively, of the First United States Volunteers in Porto Rico during the Spanish-American War. He resigned from Squadron A as Captain in 1907, and re-entered the service again as Captain of the First Calvary early in 1912, and shortly thereafter was promoted to Lieutenant-Colonel. In 1914 he was made Lieutenant-Colonel of the First Field Artillery and Colonel of that organization in 1917.

He was a member of the American Society of Civil Engineers, the American Water Works Association, the Municipal Engineers of the City of New York, the American Society of Mechanical Engineers and the Chamber of Commerce of the State of New York.

On August 1, 1914, he was appointed Chief Engineer of the Department of Water Supply, Gas and Electricity.

On June 19, 1916, he was ordered to the Mexican border with First Field Artillery, N. G. N. Y., and entrained with his regiment for Texas July 3, 1916.

On October 9, 1916, he returned to duty in the Department of Water Supply after his return from the Mexican border and finally, on November 15, 1916, he was mustered out of the Federal service.

Colonel Smith on December 30, 1890, married Maude M. Underhill, by whom he is survived. The children of this union were Merritt Haviland, Jr., born 1891, died during the World War at Plattsburg, N. Y., and Roderick Ray, died in infancy.

Colonel Smith was a man of outstanding ability and personality. Of military bearing, strong and vigorous in every action, jovial and filled with life and humor, his friends were legion.

His last illness began in September of this year and he was retired from active duty with the City of New York on December 3rd, after a continuous service of 40 years.

WM. W. BRUSH.

SOCIETY AFFAIRS

IOWA SECTION

The twelfth annual meeting of the Iowa Section, was called to order by Chairman Homer V. Knouse in the Adam Room of the Hotel Statler at St. Louis, Missouri on Wednesday, November 3. Honorable Victor J. Miller, Mayor of St. Louis, delivered the address of welcome on behalf of the city. Chairman Knouse reponded to Mayor Miller's address on behalf of the Section. (Sixty present.)

Topic No. 1, Low Water Difficulties, was discussed by C. L. Ehrhart, John W. Pray, G. W. Cox, E. E. Wolfe, H. V. Pedersen, N. T. Veatch, Jr., W. V. Wier, Frank Lawlor, Charles R. Henderson, W. R. Gelston, A. V. Graf, L. I. Birdsall and H. V. Knouse.

Topic No. 2, Taste Troubles During the Past Year, was discussed by Jack J. Hinman, Jr., E. E. Wolfe, A. V. Graf, J. W. McEvoy, R. J. Paulette, H. H. Gerstein, L. I. Birdsall, N. T. Veatch, Jr., M. E. Flentje, W. V. Wier and W. R. Gelston.

Additional topics discussed were Water Proof Paints, by N. T. Veatch, Jr., and C. L. Ehrhart, and Electric Pumping vs. Steam Pumping, E. E. Wolfe, R. L. Baldwin, C. L. Ehrhart, W. P. Brittain and W. R. Gelston.

The Round Table Discussion was discontinued at noon and the meeting adjourned until 2:00 o'clock. Chairman Knouse appointed the following committees to report at the afternoon session of November 4:

Resolutions Committee: Chas. R. Henderson, N. T. Veatch, Jr., G. W. Cox.

Nominations Committee: Frank Lawlor, E. E. Wall, H. V. Pedersen.

Auditing Committee: C. L. Ehrhart, E. E. Wolfe.

The Section reconvened at 2:15 p.m., with forty-three present. The following papers were read:

Conservation of Iowa Water Resources, H. V. Pedersen.

Following Mr. Pedersen's paper a few remarks were made by Beekman C. Little, Secretary of the American Water Works Association, who had just arrived at the meeting place.

Unusual Operating Features of the Centralia, Illinois, Filter Plant, R. S. Rankin, read by William E. Stanley, in the absence of Mr. Rankin.

Highway Water Supplies in Missouri, W. Scott Johnson.

Lactose Brilliant Green Bile as an Aid in the Tests for Bact. Coli, Dr. Max Levine. The paper to have been presented by Dr. Levine was not presented, owing to the absence of Dr. Levine. Instead of the paper, a summary of the work on lactose brilliant green bile by Committee No. 1 of the American Water Works Association was given by Jack J. Hinman, Jr., Chairman of Committee No. 1.

An Unusual Swimming Pool Filter Plant Based on Experience at the University of Iowa, Jack J. Hinman, Jr.

The Section adjourned at 5:00 o'clock to meet again in the evening.

The evening session was called to order by Chairman Knouse at 8:15 p.m. and the following papers were presented:

Reminiscences of a Water Works Man, Dow R. Gwinn.

A Program for the Protection of Land Tunnels in Chicago, H. H. Gerstein and Arthur E. Gorman.

Sedalia, Missouri's New Half Million Dollar Water Supply (with Motion Pictures), R. E. McDonnell. This paper was read by R. L. Baldwin, in the absence of Mr. McDonnell.

The evening session adjourned at 10:00 o'clock. (Sixty-three present.)

The morning session of November 4 was opened by Chairman Knouse at 9:30 a.m. (Sixty-two present.) The following papers were presented:

Calcium and Magnesium Hydrates as Coagulating Agents, Martin E. Flentje.

Notes on the Operation of the New Water Softening Plant at Springfield, Illinois, Charles H. Spaulding.

Stream Pollution and its Effects, N. T. Veatch, Jr.

Cost Accounting on Pipe Laying Jobs, Homer V. Knouse.

The meeting adjourned at noon.

The reading of papers was again taken up at 2:15 p.m. (Sixty-nine present.)

The Franchise of the Citizens Water Company of Burlington, Iowa, Frank Lawlor.

The New Missouri River Plant, Howard Bend, L. A. Day.

The Dorr Clarifier as an Aid in Water Treatment, John Fleming.

The Pitometer Survey as an Aid in the Improvement and Maintenance of the St. Louis Distribution System, Meyer Serkes.

The American Water Works Association and its Contribution to the Water Supply Industry, Beekman C. Little.

Following Mr. Little's remarks the Section went into business session.

As none of the members of the Resolutions Committee were able to be present, the report of the committee was read by the secretary. It was moved by Mr. Jensen, seconded by Mr. Molis, that the report be approved. Carried. The report of the committee carried the following resolutions:

I. *Be It Resolved* by the Iowa Section of the American Water Works Association, that the convention held in St. Louis November 3, 4 and 5, 1926 has been a satisfactory and profitable meeting in every way. And that the members of the Section are grateful to all those who contributed time and effort in planning and carrying out the arrangements, and that the Secretary is hereby requested to extend the thanks of the Section to the proper persons.

II. *Be It Resolved* by the Iowa Section of the America Water Works Association that the Section hereby tenders its thanks and expresses its appreciation to its Chairman, Homer V. Knouse and its Secretary, Jack J. Hinman, Jr., for their unselfish services and their loyal devotion to our interests.

III. *Be It Resolved* by the Iowa Section of the American Water Works Association that the Section hereby expresses appreciation to Beekman C. Little, Secretary of our Mother Association and to other members of the American Water Works Association not belonging to the Iowa Section for their presence at this meeting and their help in making its a success.

IV. *Be It Resolved* by the Iowa Section of the American Water Works Association that whereas a motion was passed at the last meeting instructing the Secretary to inform the proper officers of the American Water Works Association that it was the desire of this Section that the next annual convention be held in Chicago, and whereas Chicago has been selected, that each member of the Iowa Section make definite plans for attending, as Chicago is almost within our own territory, and the Iowa Section should use every effort to make the convention held there successful.

The Nominating Committee, by Frank Lawlor, Chairman, brought in the following recommendations: For Chairman, J. W. McEvoy; for Vice Chairman, Thomas J. Skinker; for Directors, John W. Pray, W. Scott Johnson. It was moved by Mr. Lawlor, seconded by Mr. Jensen, that the Secretary be instructed to cast a unanimous ballot for the proposed officers. The motion was unanimously carried.

The Auditing Committee, C. L. Ehrhart, E. E. Wolfe, by Mr.

Ehrhart, Chairman, reported that the books of the Secretary had been inspected and found correct. The report was accepted.

J. Chris Jensen, of Council Bluffs, extended an invitation to the Section to meet in Council Bluffs in 1927.

It was moved by Jack J. Hinman, Jr., seconded by Mr. Lawlor, that the members of the Section residing in western Nebraska be released to the Rocky Mountain Section as a sectional organization more likely to be of service to them. It was explained that the release of these members was at the desire of the Rocky Mountain Section with the approval of the National Executive Committee. The motion was carried.

It was suggested by Mr. Lawlor that all members of the organization be urged to see to it that their local libraries carry copies of the Manual of the American Water Works Association on their shelves. The usefulness of such an arrangement in advising the public concerning current methods of water treatment was emphasized.

Announcements were made concerning the meeting of the American Water Works Association at Chicago, the Iowa Sewage Conference at Ames, the Missouri Water Works Operators School at Jefferson City and the Kansas Water Works Operators School at Lawrence. The meeting was adjourned at 5:30 p.m.

The annual dinner given by the Manufacturers' Agents was held in the Ball Room of the Hotel Statler at 6:30 p.m., November 4. An excellent dinner was served, following which there were a few short talks. An entertainment program was provided by professional entertainers secured by the Manufacturers' Agents.

At 9:00 o'clock on the morning of November 5 the members of the Section met in the lobby of the Hotel Statler and were taken by automobile to the Chain of Rocks Filter Plant for an inspection trip. Following the inspection trip the party was driven to the Garivelli Restaurant for luncheon.

In the afternoon the party drove to the new Missouri River Plant under construction at Hine. On the way to the filter plant the new one hundred million gallon service reservoir now under construction was visited. A feature of the inspection of the Missouri River Plant was the opportunity to see the driving of a seventy-five foot concrete pile for the foundation of the building which will house the wash water tanks of the new filter plant. The members of the Section disbanded following the inspection trip.

JACK J. HINMAN, JR.
Secretary.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12:** 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Chlorine Studies and some observations on taste producing substances in water, and the factors involved in treatment by the super- and de-chlorination method. NORMAN J. HOWARD and R. E. THOMPSON. Can. Eng., 51: 16, October, 1926. Paper presented at forty-fifth Convention New England Water Works Association, Providence, R. I., September, 1926. Work carried out in Toronto Laboratories has resulted in great economies in plant operation. Deals with tastes and odors in chlorinated water resulting from phenoloid substances and those of unknown origin only. Taste toubles in Toronto date back to time when sterilisation of water with calcium hypochlorite was first applied in 1910. Liquid chlorine lessened number of complaints. Taste of great intensity has periodically occurred and experimental work showed that super- and de-chlorination of the water offered a successful method of abating the condition. In the spring of 1926 a sum of $32,000 was voted for one year's treatment. Public objection to the addition of further chemical to the water resulted in the treatment being temporarily held up. A wave of taste occurred in the late summer months which was responsible for the commencement of the new process in September. The causes of the medicinal taste and odor in chlorinated water are given, with a résumé of the literature during past eight years. Decomposition of organic matter is said to produce phenoloid substances in solution. Waters either of low organic matter and free of color, or very high in organic matter, are those most liable to taste. Sodium iodide, used as prophylactic against goitre, may cause taste in chlorinated water when present in quantities as low as 10 parts per billion. Wide variations in the organic and mineral content between one supply and another do not allow of comparisons being made, particularly as to liability to taste; neither can the susceptibility be gauged or explained in the light of current knowledge. Taste in water is seasonal, the least being reported during the warm summer months. In Toronto the most severe taste periods have occurred in spring and fall. Taste is attributed to combination of phenols with stirring up of organic matter during storm periods. Estimation of small amounts of phenol by distillation test is regarded as unreliable. Details of study on taste producing substances derived from destructive distillation of coal are given in detail. Some thirty substances were examined and taste production was practically confined to the mono-substitution group, including phenol, *ortho-meta-*, and *para*-cresol, xylenol, and anisole. Characteristic chemical taste of

non-objectionable character was produced by thymol and guaiacol. Phenol, cresols, xylenol, and anisole caused the typical iodiform taste in chlorinated water. Experiments were made to determine the value of color reactions in differentiating taste producing substances by use of Folin-Dennis and Fox and Gauge reagents, but it was concluded that for this purpose the tests were of limited value. The super-chlorination method of Sir A. C. HOUSTON was found to be effective in destroying the taste-producing compounds which occur in the presence of phenol and chlorine. Two very definite conditions control the treatment, namely, a minimum quantity of applied chlorine and a definite time contact. Both of these factors must be determined upon a water supply before the treatment can be effective. An insufficient dose of chlorine or inadequate time contact will negative the treatment. In Toronto when dealing with filtered Lake Ontario water it was found that the minimum dose of chlorine varied between 10 and 12.5 pounds with a contact period of not less than one hour. Practice has shown that 12.5 pounds, or more, per million imperial gallons are necessary to destroy taste. The contact period can be greatly lessened by increasing the dose of chlorine. Two parts per million (20 pounds per million gallons) reduced the contact time on Lake Ontario water by thirty minutes. Large doses of chlorine, however, with short contact periods of ten minutes or less proved ineffective. Residual chlorine is removed by application of sulphur dioxide through a vacuum pedestal machine. A chart is given showing various doses of phenol and cresol, the requisite amounts of chlorine and the time factor involved. Cresol takes considerably less time to destroy than phenol. The super treatment was applied on a large scale in Toronto for two weeks continuously in September, 1926. It is now in continuous use, over 70 million gallons being treated daily. Control water indicated that taste would have occurred in the city supply without treatment on five out of twelve days. Estimated cost of new process is $32,000 per annum equivalent to approximately $0.80 per million gallons of water treated. Problems encountered during treatment included difficulty in maintaining cylinder gas pressure (sulphur dioxide) under high discharge conditions. This was overcome by maintaining room temperature in excess of 80°F. More sulphur dioxide was required to remove chlorine than the amount theoretically necessary, which is 32 pounds of sulphur dioxide to 35.5 of chlorine or a ratio of 0.9 to 1.0, owing to partial oxidation of the sulphurous acid by the dissolved oxygen in the water. Slight increase takes place in the non-carbonate hardness, consisting of calcium chloride and calcium sulfate and in free carbonic acid with corresponding decrease in carbonate hardness. This is approximately only 25 per cent of the normal change in hardness when alum is applied in doses of 1 grain per gallon. Dilution of super-chlorinated water before de-chlorination with untreated water is not recommended. Experiments showed that the residual chlorine in the treated water was at times just sufficient to cause taste in the whole supply when diluted with untreated water. Hydrogen-ion experiments suggested by LINN H. ENSLOW showed that when filtered water to which 0.010 parts of phenol had been added was treated with 0.25 parts of chlorine, and the pH adjusted to 5.8 with sulphuric acid no taste occurred, whereas the same sample at the normal pH of 7.7 tasted badly of iodoform. The sample which had been adjusted with sul-

phuric acid when restored to its original pH value remained tasteless. Waters must be acid or highly alkaline to avoid taste. This is important in the treatment of waters of low pH value in which alkali is employed for lessening corrosiveness. In such cases the application of chlorine prior to increasing the pH value may be a means of avoiding taste troubles. Important observations are recorded relative to the effect of sunlight on color reaction when using the *o*-tolidine method for determining free chlorine. The exposure of water containing free chlorine and *o*-tolidine to direct sunlight, interferes with the production of color and may result in grave inaccuracies being recorded. Sunlight conditions must be carefully controlled if accurate results are to be obtained. The effect is due to interference with color production and not increased rate of chlorine absorption. Detailed experiments and figures are given. A summary of all results follows with conclusions. We found in Toronto, that the post-chlorination process was more effective than the pre-chlorination treatment when applying excess chlorine (through drifting-sand plant where sedimentation is not employed). In water heavily polluted, there are probably many other substances which act on chlorine and interfere with its oxidising properties. The removal of these substances by coagulation and filtration allows the chlorine to act more directly on the phenoloid substances. In all our work we have failed to find any taste producing substance derived from the destructive distillation of coal which did not respond to the excess chlorine treatment. Tribute is paid to the work of Sir A. C. HOUSTON whose active researches formed the basis of the Toronto work.—*Norman J. Howard.*

Additions to Seattle Works. Eng. News-Rec., **96**: 867, May 27, 1926. In development of Lake Youngs, Seattle, Wash., 2 earth-fill dams have been constructed which will raise lake level about 20 feet and provide available storage of 4,000 m.g. Outlet tunnel, which is concrete-lined, 8 feet in diameter and 11,000 feet long, has also been completed. A 54-inch steel pipe line 5 miles long will be constructed from existing Cedar River pipe lines to reservoirs in north end of city, and a 10-mile gravity aqueduct from Cedar River to Lake Youngs is proposed. To serve higher levels there are being provided two 1-m.g. standpipes and two 2,000-g.p.m. pumps driven by 300-h.p. motors, each operating under 270-foot total lift.—*R. E. Thompson.*

Hetch-Hetchy Progress. Eng. News-Rec., **96**: 867, May 27, 1926. Preliminary work on San Joaquin section of Hetch Hetchy aqueduct is progressing under $10,000,000 bond issue voted by San Francisco late in 1924. Bond issue of $23,000,000 to complete this aqueduct will be requested about 3 years hence.—*R. E. Thompson.*

Good Progress on East Bay Project. Eng. News-Rec., **96**: 867, May 27, 1926. Mokelumne River project for ultimate 200-m.g.d. supply through 90-mile conduit to East Bay Municipal Utilities District has progressed in 42-mile section between the district and San Joaquin River, from which emergency supply may be taken.—*R. E. Thompson.*

Los Angeles Reaching Out for Colorado River. Eng. News-Rec., **96**: 867, May 27, 1926. Completion of St. Francis dam adds 38,000 acre-feet to capacity of Los Angeles aqueduct storage system, which now comprises 12 reservoirs holding 30,000 m.g. All the city's present sources can be depended on to produce only 300 m.g.d. During 3-month period last year domestic consumption averaged 146 m.g.d., and maximum was 205 m.g.d. Bond issues totalling $2,100,000 for proposed Colorado River aqueduct were voted in 1924 and 1925 and plans are being prepared for this project which involves an infiltration canal along river.—*R. E. Thompson.*

Specifying Concrete by Water-Cement Ratio Alone. F. R. McMillan. Eng. News-Rec., **96**: 698-700, 1926. Procedure employed in applying specifications based solely on water-cement ratio in construction of new building of Portland Cement Association in Chicago is described. The proportion of aggregates was governed entirely by the requirements of workability, with single limitation that the coarse aggregate should not be less in amount than the fine, nor more than twice the fine. The maximum water-cement ratios specified were: (1) for 2900 pounds per square inch concrete, 6 U. S. gallons per sack (94 pounds) of cement; (2) for 2000-pounds per square inch concrete, 7½ gallons per sack. A curve for proportioning concrete by water-cement ratio is given and its application to small jobs is described.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Flow of Water in 54-Inch Concrete Conduit, Denver, Colo. Fred C. Scobey. Eng.-Rec., **96**: 678-80, April 29, 1926. Flow tests on 54-inch concrete conduit constructed by Denver municipal water works in 1921 and 1924 are described. These and similar tests carried out on same size pipe at Tulsa, Okla., in 1924, indicate that Scobey formula, with coefficient $C_s = 0.370$, is very conservative. Capacity found was 15 per cent greater than that accepted for best conduit a few years ago. It was observed that the 1921 pipe had lower friction factor than 1924 pipe, probably due to very thin but slick coat of slime in former. Pipe line, which will ultimately extend from Kassler filters to Capitol reservoir, was constructed of precast units in 12-foot lengths, heavily reinforced with steel hoops. Joints, which were filled with neat cement after placing lead gasket and calking, can be located by color only, not by touch. Life of pipe is estimated at 70-100 years.—*R. E. Thompson.*

Pipe Drilling Standard Holds Two Drills. W. W. Monk. Eng. News-Rec., **96**: 871, May 27, 1926. Brief illustrated description.—*R. E. Thompson.*

New Bay City, Mich., Water Works Displaces Two Old Plants. J. W. Ellms. Eng. News-Rec., **96**: 682-3, April 29, 1926. Bay City is divided into two sections by Saginaw River, and each section was formerly supplied from a separate water works. New plant, which supplies entire city, consists of new intake crib 4000 feet from shore in Saginaw Bay, 48-inch lock-bar steel intake pipe, 2 hydraulic-jump mixing flumes, 2 baffled 2-m.g. coagulation basins, providing detention period of nearly 5 hours at maximum plant capacity of 20 m.g.d., ten 2-m.g.d. mechanical filters designed for high velocity wash, and a 4.8-m.g filtered water reservoir. One manifold serves all laterals of filter strainer

system, which was designed on basis of experiments which showed that correct ratio of cross-sectional area of manifold to sum of cross-sectional areas of laterals for uniform distribution is 2:1. Gravel and sand layers are 20 and 30 inches in thickness respectively, former being graded from ⅛ to 2½ inches in diameter and latter having effective size of 0.36 mm. and uniformity coefficient of 1.74. Adjustable gutters permit variation in rate of back-wash.—*R. E. Thompson.*

Albuquerque, N. M. Eng. News-Rec., **96**: 694–5, April 29, 1926. Water supply of Albuquerque is obtained from 35 wells varying in depth from 60 to 200 feet. Town is 100 per cent metered and average per capita consumption is 100 gallons daily, maximum being 175 gallons. Minimum water rate is $1.70 per month for 6000 gallons, with rate of 15 cents per 1000 gallons above this amount in summer and 30 cents in winter. Estimated population is 26,000.—*R. E. Thompson.*

Giants Spread Car-Dumped Fill for Alouette Dam. C. E. BLEE. Eng. News-Rec., **96**: 696–7, April 29, 1926. Construction of Alouette dam of British Columbia Electric Railway Co., Ltd., is described and illustrated. Dam consists of earth fill placed by semi-hydraulic method, 1000 feet long on crest with maximum height of 63 feet above stream bed, upstream face of which is paved with hard hand-placed rock.—*R. E. Thompson.*

Uniform Aggregate Important in Concrete Control. STANTON WALKER. Eng. News-Rec., **96**: 728, May 6, 1926. It is emphasized that knowledge gained by recent researches on concrete control does not eliminate necessity of employing properly prepared and graded aggregates.—*R. E. Thompson.*

Manifold and Anchorage Combined in Pit Three Penstock. Eng. News-Rec., **96**: 728–9, May 6, 1926. Brief illustrated description of transition from 19-foot concrete-lined tunnel to three 10 foot 9 inch steel penstocks in recently completed Pit 3 plant of Pacific Gas and Electric Co.—*R. E. Thompson.*

Jarvis's Study of Flood Flow Extended. Eng. News-Rec., **96**: 737, May 6, 1926. Flow formula advocated by C. S. JARVIS: $Q = p\ 10{,}000\ \sqrt{M}$, where Q is maximum flow in second feet, M, drainage area in square miles, and p, that fraction of maximum flow possible in any region that occurs in the particular region or particular stream involved, was found to give results for 5 streams which agreed with data in possession of others. Values of p adopted were estimated from known flood flows of nearby streams, and ranged from 0.10 to 0.48. Percentage values of this fraction has been found to be roughly equal to average annual run-off (inches) for drainage area.—*R. E. Thompson.*

Flood-Protection Plan Proposed for Paris District. E. MAYNARD. Eng. News-Rec., **96**: 773, May 13, 1926. It is planned to intercept waters of Marne River at Neuilly, and by means of regulating dam carry flood waters first through section of gravity canal, then raise them by electrically-driven centrifugal pumps to small divide, whence by pipe and open channel they will

be diverted into Seine at La Briche. Cost of entire works is estimated at 285,000,000 francs, plus 7,500,000 for power for operation during period of 25 days, the average time of flood danger.—*R. E. Thompson.*

Replace Cast-Iron Turbine Runners Quickly After Failure. Eng. News-Rec., 96: 764, May 13, 1926. Cast-iron runners of the two 20,000-h.p. vertical reaction turbines of Copco No. 2 plant of California Oregon Power Co. on Klamath River, failed in service November 7, 1925, and January 17, 1926, respectively. Replacement was made in 60 days from time of first shutdown. —*R. E. Thompson.*

Old Earth Dam on the Pequannock in Northern New Jersey. J. ALBERT HOLMES. Eng. News-Rec., 96: 765, May 13, 1926. Brief illustrated description of old dam on Pequannock River constructed of glacial drift.—*R. E. Thompson.*

Pneumatic Filter-Alum Conveyor for Minneapolis Water Filters. J. A. JENSEN. Eng. News-Rec., 96: 766–8, May 13, 1926. New Fridley 40-m.g.d. (160 m.g.d. ultimate) filter plant at Minneapolis will supplement supply from filters at Columbia Heights. Source of supply for both plants is Mississippi River. The pneumatic conveyors installed, with which granulated alum can be moved from cars to primary storage, or from cars and primary storage to service hoppers, at rate of 12 and 8 tons per hour respectively, are described and illustrated. It has been guaranteed that loss due to escape of dust will not exceed 0.1 per cent. Disadvantage of system where volumetric dry feed machines are employed is that stratification of coagulant interferes with accuracy of delivery. This will be remedied by method of checking by weighing.—*R. E. Thompson.*

Topeka, Kans. Eng. News-Rec., 96: 769–71, May 13, 1926. New $1,500,000 mechanical filter plant of 5-m.g.d. capacity was put in service in spring of 1924 for treating Kansas River water. Prior to this, water was drawn from 250 sand points placed along river, which finally became so clogged that sufficient supply was no longer available.—*R. E. Thompson.*

Lining an Earth Spillway Channel with Concrete. C. E. BLEE. Eng. News-Rec., 96: 777–8, May 13, 1926. Brief illustrated description of paving and lining of spillway of Alouette dam with concrete. Water drop of 38 feet was accomplished by means of ogee section, hydraulic jump being employed to dissipate destructive water velocities.—*R. E. Thompson.*

Arch Dam of Thin Section now in Service on Salt River. Eng. News-Rec., 96: 778, May 13, 1926. Brief illustrated description of Mormon Flat dam, completed last year on Salt River in Arizona, which increases storage capacity on irrigation project by 90,000 acre-feet and makes possible development of 20,000 h.p. Dam was designed by cylinder formula and stresses were calculated according to theory of the elastic arch. Height is 210 feet, with base thickness of 22 feet and thickness under roadway on crest of 8 feet. Crest

length is 326 feet, exclusive of overflow gravity section which is 90 feet long, and maximum height, 93 feet. Total of 43,000 cubic yards of concrete was used in structure. Closure of spillway is effected by 9 Taintor gates, 27 feet long by 23 feet wide, weighing 27 tons each.—*R. E. Thompson.*

Lime-Silica Index as Measure of Cement Quality. THADDEUS MERRIMAN. Eng. News-Rec., 96: 648-50, 1926. The principal components of portland cement are (1) $3CaO \cdot Al_2O_3$, (2) $3CaO \cdot SiO_2$, (3) $2CaO \cdot SiO_2$, (4) MgO, (5) $3CaO \cdot Fe_2O_3$, and (6) $CaSO_4 \cdot 2H_2O$, of which only (2) and (3) are believed to possess cementing qualities, the former being the most important. The CaO–SiO_2 index is the percentage of CaO in the cement which is available for combination with the available SiO_2 divided by the latter; the available SiO_2 being the total SiO_2 less the insoluble residue, and the available CaO, the total CaO less that in combination with Al_2O_3, Fe_2O_3, and SO_3. A cement in which all the CaO is combined in form of the desirable $3CaO \cdot SiO_2$ would have an index of 2.80. The cement which shows the highest strength at 7 days for a given CaO–SiO_2 index, or the lowest index for a given strength, has been the most thoroughly made and calcined. It is therefore indicated that strength alone is not a criterion of either cement value or quality. Fine grinding will not compensate for either a deficiency of cement value or for underburning of product. The tensile strength and CaO-SiO_2 index for 298 cements are shown graphically. Practical applications of considerations advanced in the formulation of requirements of cement quality are outlined.—*R. E. Thompson (Courtesy Chem. Abst.).*

Chemical Cost for Reducing Water Hardness. Eng. News.-Rec., 96: 726, May 6, 1926. Brief data regarding softening at Columbus, Ohio, is given. Cost of chemicals during 1925 was 10.2 cents for each part of hardness removed, compared with average of 10.24 cents for 17 years from 1909 to 1925. Minimum average annual cost was 5.2 cents in 1915 and maximum 15.3 in 1918. Average reduction in hardness during 1925 was 206, average hardness of raw water being 298.—*R. E. Thompson.*

Water Power Developments on the Salt River in Arizona. Eng. News-Rec., 96: 978-9, June 17, 1926. Brief data given on power projects on Salt and Verde Rivers.—*R. E. Thompson.*

Tests of Vibrolithic Concrete. L. W. TELLER. Eng. News-Rec., 96: 779, May 13, 1926. The vibrolithic process was found to give a more uniform product, which exhibited greater strength at 28 days for a given cement content than normal concrete.—*R. E. Thompson (Courtesy Chem. Absts.).*

Denver Societies Hold Money Wasted on Flood Control Work. Eng. News-Rec., 96: 806-7, May 20, 1926. Notes from report of Colorado Engineering Council, comprising 14 engineering and technical societies, are given, in which city administration is severely censured for waste of money in building embankments which are "not of a sufficiently substantial nature to ensure the safe carrying capacity that otherwise would be possible with the levee heights

adopted." Comprehensive engineering study of Denver flood problem is recommended.—*R. E. Thompson.*

Asphalt Grouting Under Hales Bar Dam. GEO. W. CHRISTIANS. Eng. News-Rec., 96: 798–802, May 20, 1926. During construction of Hales Bar concrete dam over Tennessee River at Guild, Tenn., great difficulty was experienced in getting foundations down to satisfactory bed rock, and pneumatic caissons were sunk throughout most of dam. On completion of work considerable leakage developed, and after various methods to correct this condition had failed, holes were drilled from tunnel in dam into rock below in endeavour to locate sections through which leakage was occurring. Crevices in the rock were found within fairly well defined limits, which are believed to be due to solution and disintegration which proceed in advance of mechanical erosion by river flow. The condition does not materially affect stability or permanence of dam. One exceptional crevice showed water flow velocity of about 360 feet per minute. Instruments devised for investigation, a crevice meter and a flow meter, are described. Fissures were sealed by means of asphalt grouting. Procedure employed, for which patents have been granted, is described in detail. Advantages of method over cement grouting are outlined. All of leakage was not remedied, but it was reduced to such an extent that it was thought that expense of locating remainder was not justified. Method was also used to stop leaks on cliff face, against 150-foot difference in water level, below another dam.—*R. E. Thompson.*

Adaption of Slide Rule for Computing Flow in Pipes and Open Channels. J. B. LIPPINCOTT. Eng. News-Rec., 96: 658–9, 1926. A curve showing the approximate relation of Williams and Hazen's "c" and Kutter's "n" for open channels is given which was prepared to facilitate computation of flow with the Williams and Hazen slide rule.—*R. E. Thompson* (*Courtesy Chem. Absts.*).

Factors Considered in Designing Largest Pumping Station. LORAN D. GAYTON. Eng. News-Rec., 96: 838–53, May 27, 1926. Factors considered in determining the need and location, tunnel requirements, and equipment for the 300-m.g.d. Western Ave. Station, Chicago, are discussed in detail. Steam-turbine-geared centrifugal pumps were selected as being most economical in overall operating costs. While triple-expansion pumping engines are by far the most economical in steam consumption, initial cost, buildings required, labor cost, etc., make cost of operation of these units 14 per cent higher than that of turbo-centrifugals. Cost of operation of Diesel station is approximately same as of steam-turbine station, but mechanical difficulties involved prohibit employment of former. Cost of operation of motor-driven centrifugals is about 10 per cent higher than of steam-turbines. Study of load curve showed that 3 pumps having capacity range of 50–75 m.g.d. and total head range of 107–150 feet would give ideal operating conditions. Fourth unit was added for reserve. Specifications for turbines, gears, pumps, and condensers are given. Lowest bid received was for compound turbines with guaranteed water rate of 9.5 pounds per h.p.-hr., or duty of 208,000,000 foot pounds per 1000 pounds of steam at most efficient point. Details of steam

generating equipment are included. Mechanical stokers, powdered coal, and oil-fired boilers were considered, stokers being adopted. In Chicago, with bituminous screenings at $2.90 per ton and oil at 5 cents per gallon, cost of steam from fuel oil is approximately double that from coal. An evaporator plant was installed for distilling make-up water, which amounts to 2 per cent. Estimation of relative costs of distillation and zeolite softening indicated that annual operating costs would be $500 less with former method, representing net earning of 12.8 per cent on added investment of $4000 to purchase evaporator plant. Project is about 60 per cent completed.—*R. E. Thompson.*

Experience with Riveted Pipe in San Francisco Water Works. GEO. W. PRACY. Eng. News-Rec., **96**: 844–6, May 27, 1926. Riveting of plates into cylinders and joining then to form pipes was originated by a miner in early days of California. Herman Schussler, who entered employ of Spring Valley Water Company in 1864, developed the idea until by 1875 a considerable mileage of riveted pipe was in use. Experience with such pipe of 16–44 inches diameter, some of which has been in use 54 years, indicates that riveted pipe is preferable to cast-iron pipe in most cases. Prior to 1907, all riveted lines laid, except submarine pipes, were made of best grade laminated wrought iron. Since that date steel has been employed. During past 16 years, only trouble experienced has been in 2 sections within limited districts which were affected by electrolysis. Both these lines passed directly in front of a substation. Bonding of pipes to electric return system eliminated difficulty. Estimated relative net costs of large mains after 40 years' use, on basis of installations of latter made during past few years, are $418,800 and $278,800 respectively, for cast iron and riveted pipe. Most important element in prolonging life of thin metal pipe is the dip, including prevention of damage to same during installation. Lately all pipes have been wrapped with prepared paper almost identical with roofing felt, in addition to being dipped in asphalt. —*R. E. Thompson.*

Well-Water Development with Air Lifts at Lansing, Mich. L. R. HOWSON Eng. News-Rec., **96**: 846–8, May 27, 1926. History of water supply of Lansing is reviewed. In recent study, additional wells were selected as source of increased supply in preference to filtered and chlorinated supply from Grand River, owing to natural purity of ground water and its constant temperature of about 50°F. Temperature of river water varies from 32° to 80°. New Riverside Station development consists of 12 wells located in straight line parallel to Red Cedar River at intervals of 300–400 feet. Air-lift method of pumping was selected as this system possesses following advantages over electrically-driven deep-well turbines: (1) lower annual cost; (2) greater reliability; and (3) greater flexibility. Tests of air-lift equipment showed overall efficiencies of 34 per cent. Cedar St. station was also rehabilitated and equipped with air-lift apparatus. Hardness of supply is, 330 p.p.m. Softening will probably be employed in near future.—*R. E. Thompson.*

Charleston, S. C. Builds 2,000,000-Gallon Elevated Steel Tank. Eng. News-Rec., **96**: 848–9, May 27, 1926. Illustrated description of 2,000,000-gallon

elevated tank on 80-foot tower, which is probably largest elevated tank with self-supporting bottom built to date. Tank shell above curved bottom is 80 feet in diameter by 35 feet high, and is not surmounted by roof. Ellipsoidal bottom is 26 feet, terminating in 14-foot steel riser pipe 54 feet high. Overflow trough is 18 inches by 18 inches, with 12-inch galvanized iron down pipe. Total weight of steel in structure is 1,350,000 pounds, and total water load 17,000,000 pounds. Steel in tank, cylinder and overflow trough is of copper-bearing grade. Exterior will be painted with 2 coats of red lead, and finishing coat of aluminum. Bitumastic enamel will be applied to interior. Tank was constructed to relieve wide fluctuations in pressure and load on pumping station caused by irregular demands by industrial plants, which consume approximately one-third of total water supplied.—*R. E. Thompson.*

Unique Reservoir Lining for Port Angeles, Wash. M. P. HATCHER and E. L. FERGUSON. Eng. News-Rec., **96**: 859–61, May 27, 1926. Port Angeles, a city of 10,000 people, recently completed a water works program involving expenditure of $625,000, about $280,000 of this amount being paid for privately owned system and remainder for development of new 11-m.g.d. supply, 6-m.g. reservoir, and improvements to distribution system. With old supply of 3 m.g.d., city has total available supply of 14 m.g.d. or 1400 gallons per capita. New supply is taken from Morse Creek. Concrete dam about 8 miles from city diverts water through 24- and 20-inch gravity wood conduit to reservoir, from which water flows by gravity to distribution system. Reservoir is in excavation and embankment, with side slopes of 1.75 to 1 and top embankment width of 15–30 feet. Slopes are lined with reinforced concrete slabs 5 inches thick, and bottom with 6-inch slabs. Lining is described in detail. Total cost of reservoir was $70,000.—*R. E. Thompson.*

Prehydration of Cement in New Method of Concrete Mixing. WILLARD B. JONES. Eng. News-Rec., **96**: 850 (1926). During the construction of the Montebello filtration plant at Baltimore, Md., a large part of concrete was mixed by hydrating with required amount of water prior to mixing with the aggregate. This method produces a product of uniformly good quality, eliminates possibility of lumps of cement in the concrete, provides facilities for handling the grout when bonding new concrete with an old pour, and makes possible a decided reduction in time of mixing. Fifteen seconds in mixer was found to be sufficient to give concrete of normal strength. The prehydration process and machine employed, which is described, have been patented.—*R. E. Thompson (Courtesy Chem. Abst.).*

Building Cellular Wall Cofferdam, St. Louis Intake. JOHN C. PRITCHARD. Eng. News-Rec., **96**: 862–5, May 27, 1926. Construction of intake and pump pit for St. Louis intake at Howard Bend on Missouri River is described and illustrated. Elevation of river bank at site is about 42, and extreme high and low water levels, 43 and 11 respectively. Bottom of low service pit was made 0.5 and ultimate depth of excavation, 14. Entire site, which is partly inshore and partly in river, was excavated to El. 30, to reduce depth of cofferdam. Owing to dimensions, a cellular cofferdam was adopted, consisting of 30 closed

cells. Steel piles weighing 38 pounds per foot, 56 feet in length, were employed total number being 1666. High service pit, located immediately behind low service pit, was also cofferdam job, but this was much simpler and depth was 29 feet less, permitting use of single line of 34-foot piles.—*R. E. Thompson.*

"Multiple-Dome" Design Adopted for Coolidge Dam. Eng. News-Rec., 96: 865, May 27, 1926. Multiple-dome design has been adopted for Coolidge Dam across Gila River in irrigation and flood conservation project in Arizona. Design differs from ordinary multiple-arch design in magnitude of its arch spans and in doming of arches in vertical plane.—*R. E. Thompson.*

Weir-stick for Use on Narrow Canals or Streams. T. A. HAYDEN. Eng. News-Rec., 96: 850–1 (1926). The Clausen Pierce weir stick, designed by I. M. CLAUSEN and RALPH PIERCE, consisting of rod 5 feet long, 1 inch thick, and 1¾ inch wide, graduated in Miners' inches per inch width of weir, is described. The rod, which can be used on any narrow ditch where a weir or gate with free fall exists, or can be installed, has greatly facilitated the operation of the Salt River irrigation project.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Moot Questions on the Design of Lake Intakes. PAUL HANSEN. Eng. News-Rec., 96: 861–2, May 27, 1926. Brief discussion of design of intakes in which tabulated data is given for number of existing structures. Depth should be sufficient to avoid influence of wave action, undertow, and resulting turbidity. In Lake Michigan these influences probably do not extend below 40 feet. Difficulties due to frazil ice may be avoided by extending intake to depth such that vortices cannot reach from surface to intake level. Depth required is not definitely known, but not many intakes give trouble at 30 feet or more. Extending Marquette, Mich., intake to depth of 56 feet was unsuccessful in avoiding phenol wastes and zone of seasonal turn-over. If intakes are placed at reasonable depth it is questionable if any special form of intake structure is necessary. An intake well decreases the capacity of an intake, even when maximum feasible siphon action of downturned inlet pipe is utilized. At South Haven, where intake tends to fill with sand, it has been found that an adequate volume of water with but little more sand can be obtained more readily by direct pumping from intake pipe than by pumping from intake well. At Lake Forest it was found that with centrifugal pumps more water and better pumping conditions could be obtained by connecting pumps directly with the intake.—*R. E. Thompson.*

Detroit Experimental Filter Plant. Eng. News-Rec., 96: 871, May 27, 1926 Brief illustrated description of Detroit experimental filter plant which was constructed for studying design of coagulation and sedimentation basins.—*R. E. Thompson.*

Town of 4,000 Spends $90 per Capita for Water and Sewage. WEBSTER L. BENHAM. Eng. News-Rec., 96: 852–5, 1926. The new water supply system of Elk City, Okla., consists of a dam impounding water from a drainage

area of 23½ square miles in a reservoir of 250 million gallons capacity, aërator, mixing chamber, coagulation basins, two 0.5-million gallons per day mechanical filters, and chlorination equipment. The cost of the entire project, including extensions to the distribution system and sewer improvements, was $356,000. Dam is of earth, with concrete cut-off core-wall, approximately 850 feet in length, and there is also a shallow dike about 1000 feet long. Maximum height of dam is 30 feet, and width at top is 16 feet. It was necessary to carry core-wall to depth of 30 feet below ground level for several hundred feet to prevent loss of water. Slope of water side was made 3 to 1, and that of downstream side, 2 to 1, former being paved with reinforced-concrete slabs 4 inches thick, laid in sections with expansion joints of asphalt.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Baffle Piers at Toe of Dam Dispel Energy of Flow. I. C. Steele. Eng. News-Rec., **96**: 886–9, June 3, 1926. Unusual foundation conditions at site for diversion dam for Pit No. 3 power development of Pacific Gas and Electric Co., influenced adoption of concrete baffle piers in conjunction with lining of river channel for distance of 150 feet downstream to guard against possible scouring and erosion at toe of dam. A small concrete diversion dam on Rock Creek, the waters of which are diverted into Pit No. 3 tunnel, was constructed as 1/20 scale model of main structure and experiments were carried out to determine proper shape, sizes and location of piers. Main dam is an ogee spillway type concrete structure, 112 feet in height from foundation level to crest, with spillway section 18 feet deep and 267 feet long, designed to pass flood of 70,000 second-feet. Dam is arched in plan to radius of 500 feet. Concrete apron has minimum thickness of 4 feet and extends maximum distance of 150 feet downstream from toe of dam.—*R. E. Thompson.*

High Duty of St. Paul Cross-Compound Pumping Units. J. W. Kelsey. Eng. News-Rec., **96**: 855, May 27, 1926. Brief description of unusual combination of 3 horizontal cross-compound pumping engines which comprise part of 5 year program of water works improvements just being completed at St. Paul, Minn. Water ends are identical, each having capacity of 15 m.g.d., but steam ends vary to provide for 3 different heads, 70, 175 and 220 feet. Extremely high duties were obtained in installation tests, approximate figures per 1000 pounds of steam, in millions of foot-pounds, being 160 for low-lift, and 182 for both intermediate and high-lifts. Boilers are horizontal water tube type, carrying 200 pounds gage steam pressure. Steam is delivered to engine throttle at about 100° superheat. Boilers are equipped with underfeed stokers and ashes are conveyed by vacuum system to hopper in bottom of smokestack, where they can be delivered through chute to truck. All auxiliaries are steam-operated, exhaust being employed to heat boiler feed in open feed-water heater. During 1925 all 3 pumps discharged 7670 m.g. by plunger displacement and 3.47 per cent less by venturi, which represents slip. Station duty in foot-pounds per B.t.u. was 80.7, and in foot-pounds per 100 pound of coal 106,944,000. Pumping cost was $7.70 per m.g., or 5 cents per foot head.—*R. E. Thompson.*

Boston To Go To Ware and Swift Rivers for More Water. Eng. News-Rec., 96: 934–5, June 10, 1926. After 7 years of agitation and engineering investigation, a bill for additional water supply has been passed by Massachusetts Legislature. Under terms of bill, special construction commission is created to: (1) divert flood flow of Ware River in excess of 85 m.g.d., into Wachusett reservoir through aqueduct or tunnel large enough to carry proposed supply from River; (2) acquire land and water rights on Swift River watershed for future development under plan to be prepared by commission and submitted to Legislature in January 1927; and (3) make plans and cost estimates and submit draft to legislature on filtration and chlorination of both Cochituate and Sudbury sources of supply (now used only in case of emergency owing to pollution). Act provides fund of $15,000,000 for carrying our construction, of which $14,000,000 will be derived from state bonds to be charged upon several towns and cities sharing metropolitan supply, and $1,000,000 from City of Worcester in relinquishing all rights in Nashua River above Wachusett reservoir, except for supply of 10 m.g.d. from Quinapoxet River.—*R. E. Thompson.*

New Collector for Sampling of Filter Sand. AUGUST V. GRAF. Eng. News-Rec., 96: 868–9, 1926. Apparatus for sampling sand of mechanical filters designed by JOHN ALLGEYER is described which consists of 2-inch split and hinged brass pipe which is lowered vertically into sand bed during washing and withdrawn after wash water has been shut off and filter completely drained. —*R. E. Thompson* (*Courtesy Chem. Absts.*).

Laying 54-inch Main Across Mississippi River at Minneapolis. JOHN A. JENSEN. Eng. News-Rec., 96: 868, May 27, 1926. During 1924–5 Minneapolis Water Dept. laid new line of 50- and 54-inch pipe to connect new Fridley filtration plant with existing supply main. The 54-inch portion of line crosses Mississippi River at point where width is 600 feet and depth 4–7 feet. Pipe was of 2-inch riveted steel and was delivered in 30-foot lengths. In installing pipe in trench, front end was closed with torpedo cone head, and as succeeding sections were added it was pulled into river 30 feet to the pull. Length of crossing was 743.9 feet. Total labor cost was $7,650.26 or $10.28 per linear foot.—*R. E. Thompson.*

Flood Control Controversy in Los Angeles County. Eng. News-Rec., 96: 890–2, June 3, 1926. Data given regarding flood control controversy in Los Angeles County, California, in connection with which hearings have been recently held before committee of federal engineers. Several dams have been completed and Pacoima Dam, which is 375 feet in height, is under construction. There has been general objection to scheme of flood protection and to site chosen for proposed San Gabriel River Dam which, when completed, would be by far the highest dam in the world, rising approximately 500 feet above lowest part of foundation.—*R. E. Thompson.*

Device for Measuring Aggregates at the Concrete Mixer. Eng. News-Rec., 96: 1031, June 24, 1926. Brief illustrated description of device, which can be

operated by mixer-man, for measuring 3 sizes of aggregate by volume simultaneously.—*R. E. Thompson.*

How Turbid Colorado River Water Was Made Fit to Drink. IRVING C. HARRIS. Eng. News-Rec., 96: 896-7, 1926. The water supply of El Centro, Calif., is drawn from an irrigation canal carrying Colorado River water, which contains about 1 per cent by weight of sediment. The water flows through 8 settling reservoirs which provide retention period of 5–10 days, and is filtered through two 24 by 200-foot filters of 5 million gallons per day capacity at normal rate of 22.7 million gallons per acre per day. Other than chlorination of filter effluent, no chemical treatment is employed. The filters are cleaned with a traveling Blaisdell washer. Sedimentation removes approximately 90 per cent of bacteria from raw water and the filters about 90 per cent of those remaining. Aëration is desirable to reduce tastes due to vegetable growths in canals. Content of soluble salts averages 300-400 p.p.m. Cast-iron pipe is employed, as wrought-iron has very short life under existing soil conditions. All services are of lead and all are metered. Water rates are 16 cents per 1000 gallons for first 20,000 gallons with minimum charge of $2, which covers first 12,500 gallons used. All water used between 20,000 and 100,000 gallons is charged at 15 cents and all in excess of 100,000 at 14 cents per 100 gallons. Consumption is 1-2 m.g.d. and population 6-7000. Removal of silt from reservoirs is considerable item of expense. Several acres have been covered to depth of 20 feet or more and 10 acres of land have been purchased for future operations.—*R. E. Thompson* (*Courtesy Chem. Absts.*).

Weighted Canvas Controls Quicksand While Concete is Poured. R. J. REIGELUTH. Eng. News-Rec., 96: 1033, June 24, 1926. During construction of tunnel within 10 feet of power house of Steel Power Plant of United Illuminating Company, Bridgeport, Conn., quicksand was encountered 18 feet below high water level. Excavation was carried out inside cofferdam with clamshell bucket, and when quicksand was struck the area was flooded and excavation continued by operating clamshell under water. Bottom was leveled with water jet and one section was covered with 25-ounce duck held in place by 500-pound precast concrete blocks. Concrete mat, 5 feet thick, was then deposited, and excavation was pumped dry after period of 21 days. —*R. E. Thompson.*

Correct Chart for Converting Kutter's "n" into Hazen and Williams' "c". R. DE L. FRENCH and F. M. WOOD. Eng. News-Rec., 96: 954-5, 1926. Chart given and method of use described briefly.—*R. E. Thompson* (*Courtesy Chem. Absts.*).

Low Leakage in 42-inch Submarine Pipe. Eng. News-Rec., 96: 909, June 3, 1926. Final test recently made by City of San Francisco on 404.6-foot length of 42-inch flexible cast-iron submarine pipe across Newark Slough showed leakage of only 9.7 gallons in 24 hours under water pressure of 170 pounds per square inch, almost all of which was accounted for at end flange connections used for test. Specified allowable leakage was 280 gallons per

hour. One joint required recalking. Main Bay crossing, 2750 feet long, is also believed to be tight, within limits of specification.—*R. E. Thompson.*

Substitute Surface for Jet Condensers at Wart Station, Buffalo. S. E. ROOF. Eng. News-Rec., 96: 869-70, May 27, 1926. Surface condensers are being substituted for jet condensers in the five 30-m.g.d. vertical triple-expansion pumping engines at Buffalo. Specifications require 1800 square feet of cooling surface for each pump. Vacuum within 1 inch of barometer reading can be maintained without difficulty in two pumps completed.—*R. E. Thompson.*

Spray Hot Water to Cool for Domestic Use. Eng. News-Rec., 95: 870–1, May 27, 1926. Water supply of Highland Park, suburb of Dallas, Tex., is obtained from 2 artesian wells 2865 feet deep. Temperature of water is 110°F., and until cooling system was installed in 1924 very little reduction in temperature occurred before water was delivered to consumer. Cooling system consists of spray nozzles through which water is sprayed 7 feet in air. This reduces temperature to average of 84° during night and 88° during day.—*R. E. Thompson.*

The Importance of the Uniform Distribution of Chlorine in Pool Waters of Bathhouses. G. ELKELES. Gesundheits-Ingenieur, 49: 11, 151–153, March 13, 1926.—*Jack J. Hinman, Jr. (Courtesy Chem. Absts.).*

Albany to Have $11,000,000 Water System. Health News (N. Y.), 3: 163, October 11, 1926. Supply is to come from 3 practically uninhabited watersheds on the Hannacroix Basic basin by gravity. Storage dam at Alcove will impound 4 billion gallons and reservoir at Indian Fields will impound 8 billion gallons. Water will be stored six months, chlorinated, aerated, chlorinated a second time, and distributed. It is expected to supply 30 m.g.d. —*Jack J. Hinman, Jr. (Courtesy Chem. Absts.).*

Alleged Water Contamination Made Basis for Suit. Health News (N. Y.), 3: 162, October 11, 1926. Three suits totalling $30,000 have been filed against city of Albany for alleged damages and breach of warranty. It is alleged that typhoid fever was contracted from the city water.—*Jack J. Hinman, Jr. (Courtesy Chem. Absts.).*

Paper Mill Water Supply for Nekoos Edwards Paper Company, Port Edwards, Wisconsin. E. P. GLEASON and C. F. WATSON, Bull Assoc. State Eng. Soc., 1: 55, 1926. Water for paper making should show practically no suspended matter and not more than 15 p.p.m. true color, 0.2 p.p.m. Mn, or 0.5 p.p.m. Fe. Water from Four Mile Creek containing 60 p.p m. color, 2.5-3.0 p.p.m. Fe and practically no Mn was found to be satisfactory if treated with 3 grains per gallon aluminium sulphate and given long sedimentation. A basin of 12 acres providing 48 hours sedimentation was constructed and found to yield a suitable water after treatment.—*Jack J. Hinman, Jr. (Courtesy Chem. Absts.).*

Water Supply for Arlington County, Virginia. CLYDE P. ROSS. Mun. & County Eng., **70**: 188–91, 1926. About one million gallons per day are required for Washington and Arlington districts which had a population of 12,372 in 1920. Two alternative plans are suggested; one to obtain the supply from about 50 widely distributed wells at depths of from 100 to 150 feet, and the other to build a purification plant and obtain the supply from a surface source at considerable distance.—*C. C. Ruchhoft.*

Graphical Chemistry in Water Softening. R. L. MCNAMEE. Eng. & Cont., **65**: 285–90, 1926. Charts for estimating soap requirements, temporary hardness, degree of hardness, lime and soda ash dosage, and molecular combinations are presented.—*C. C. Ruchhoft (Courtesy Chem. Absts.).*

Repairing Break in Aqueduct. JAMES A. O'CONNOR. Eng. & Cont., **65**: 415–6, 1926. Excavation for new concrete water conduit of Washington, D. C., which parallels old 9 foot brick aqueduct, caused break in the top half of section of latter. This was repaired with a rectangular reinforced concrete section.—*C. C. Ruchhoft.*

Measuring Water Levels in Wells. G. C. HABERMEYER. Eng. & Cont., **65**: 251, 1926. Apparatus for measuring water levels in wells is described. An insulated wire and, where lighting circuits are available a lamp, otherwise two dry cells and a buzzer, are used with apparatus containing a float which closes the circuit, for lowering into the well.—*C. C. Ruchhoft.*

Accounting Methods for Water Works. HAROLD D. SMITH. Eng. & Cont., **65**: 253–56, 1926. Necessity for accurate records and occasional audits to self-supporting water works system is discussed. Accounting procedure of high type, but not necessarily uniform, is essential. Customers deposits should be handled as a trust fund, separate and intact.—*C. C. Ruchhoft.*

Water Works Statistics. Anon. Pub. Wks., **57**: 302–7, 1926. Statistics on meter rates and percentages of services metered, chemicals used in water purification, sizes of mains laid, and kinds of pipe used are tabulated for 200 cities.—*C. C. Ruchhoft.*

City Authorities Held Responsible for Typhoid: Anon. Pub. Wks., **50**: 697-8, 1926. In test case, court found officials negligent and awarded damages for illness during typhoid epidemic at Owen Sound, Ont.—*C. C. Ruchhoft.*

Some Small Water Purification Plants. W. A. HARDENBERGH and K. W. GRIMLEY. Pub. Wks., **57**: 275–279, 1926. Well and surface waters of eighteen of the thirty-five plants in Jefferson County, Alabama, serving more than fifty persons receive some treatment. Details of several small filter and chlorination plants are given.—*C. C. Ruchhoft.*

New Walton Filters of London, England. Anon. Eng. & Cont., **65**: 417–21, 1926. General layout and construction details are given. The primary filter plant has 18 open rapid rate filters with total capacity of from 18 to 36 m.g.d. Water is admitted to filter beds at maximum head of 10 feet. Filter bed has 18 inches of graded gravel and 30 inches of sand. Filtered water collection pipes are connected with compressed air and wash water systems, air being blown through to loosen sand before washing filter. From primary filters, water flows through covered clear water channel to secondary filter beds, of which there are six, with an area of $\frac{5}{8}$ acre each. There is a chlorinating and recorder house for each group of 3 filters. Sand of the secondary filters is removed for washing partly by manual labor and partly hydraulically. Washing is done in hoppers arranged in trains of four, each on a small truck. Sand thus receives four successive washings and is returned to the filter for spreading in workable layer.—*C. C. Ruchhoft.*

ABSTRACTS, SUBCOMMITTEE NO. 9

Joint Research Committee on Boiler Feedwater Studies

Boiler Water Conditioning with Special Reference to High Operating Pressure and Corrosion. R. E. Hall. Combustion, **15**: 3, Sept. 1926, pp. 156–159, 1 fig. Scope of boiler-water conditioning; prevention of scale formation on evaporating surfaces; relation between chemical used in treatment and operating pressure; control of non-condensable gases in steam by conditioning of boiler water.

The Treatment of Boiler Feedwater by Means of Evaporators (Die Aufbereitung des Speisewassers für Dampfkessel mittels Verdampferanlagen). Wintermeyer. Feuerungstechnik, **14**: 22, Aug. 15, 1926, pp. 263-266, 2 figs. Disadvantages of chemical treatment; degassing of feedwater; preparation of feedwater by evaporation, whereby condensate and distillate are precipitated as feedwater; examples of modern evaporator plants; cooling-water evaporators.

Water and Its Impurities. J. C. Moore. Power House, **20**: 17, Sept. 5, 1926, pp. 17–19. Effect of impurities in feedwater of boilers is to cause deposition of scale on interior of water-heating surfaces, in addition to deposition of mud or sediment, thus facilitating corrosion and foaming; corrosion results mainly from use of hard water; causes of hard water; how deposit becomes hard; carbonates of magnesia; alkalinity of water; test for calcium salts; treatment to prevent scale; water filtration.

Preheating Pump. E. Josse. Eng. Progress, **7**: 8, Aug. 1926, pp. 208–209, 3 figs. Details of pump manufactured by firm of F. Seiffert and Co., Berlin, novel feature of which is that boiler feedwater is heated inside pump in direct contact with bleeder steam, pump raising pressure of condensate of prime movers fed back to boilers, from condenser pressure to boiler pressure.

Concentration of Caustic Soda in Connection with Boiler Plate (Laugenkonzentrationen in Verbindungen von Kesselblechen). R. Baumann. Archiv für Wärmewirtschaft u. Dampfkesselwesen, **7**: 9, Sept. 1926, pp. 255-260, 16 figs. Results of investigation carried out for German Union of Boiler Users,

showing that supposed concentration of salts, especially of caustic soda, in rivet seams is only possible if seams are leaking and feedwater is very salty.

Boiler Corrosion on the Canadian Pacific Railway. T. W. LOWE. Boiler Maker, **26**: 8, Aug. 1926, pp. 223–226. Report on Paper entitled "Boiler Fitting and Corrosion," presented at Master Boiler Makers' Assn.

The Problem of Steam-Boiler Corrosion. F. N. SPELLER. Mech. Engrg., **48**: 10, Oct. 1926, pp. 1017–1023, 2 figs. Mechanism of corrosion; boiler feedwater; dissolved oxygen and CO_2; salt, alkali and acid content; influence of scale, organic matter, and composition of materials of construction; preventive measures; general precautions for care of boilers.

Investigation of Strongly Corroded Brass Condenser Tubes (Untersuchungen von Messingkondensatorrohren mit starker Korrosion). M. SCHWARZ. Korrosion u. Metallschutz, **2**: 1, Jan. 1926, pp. 8–17, 17 figs. Examination of tubes from two power plants showed basic zinc carbonate in corroded spots and experiments showed that cooling water attacked beta mixed crystals of brass.

Pitting of Locomotive Boilers. W. A. POWNALL. Ry. Rev., **79**: 8, Aug. 21, 1926, pp. 263–270, 5 figs. Observations of boiler corrosion in various forms.

High-Pressure Filtration of Softened Water. L. H. BIGGAR. Power Plant Eng., **30**: 19, Oct. 1, 1926, pp. 1050–1051, 1 fig. High head, fine clean sand bed of low uniformity and high porosity and removal of deposited solids give clear filtered water.